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Bovine Tuberculosis

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GENERAL CONSIDERATIONS

Historical. — The development of the present-day knowledge of the tuberculoses of animals is so intimately associated with that pertaining to the human form of the disease that the latter needs to be included in the historical considerations, without which it would be difficult to view any phase of the subject in a comprehensive manner.

The origin of the disease can only be a matter of speculation, but it seems probable that it did not assert itself in a formidable manner until civilization took definite form and after man began to shelter himself in more or less enclosed and permanent dwellings.

The more common form of the disease, consumption, was well known to the ancient writers and some of those left very accurate descriptions of its phenomena as they saw them. Egyptian mummies studied during the present century showed clearly that tuberculosis was already a human disease in the days of the Pharaohs.

However, there is but little historical evidence to prove that a definite morbid process resulting in highly characteristic lesions was at all recognized as being constantly involved in the disease. It was not until the latter part of the eighteenth century that English and French physicians described the granulations peculiar to the disease and began to speak of tubercles.

A few years later, early in the nineteenth century, the French physician, Laennec, more clearly described the tuberculous lesions and not only laid the foundations for our present knowledge of the pathologic anatomy of the disease but also made possible a more exact means of diagnosis. Long before the days of Pasteur he suspected the specific infectious nature of tuberculosis.

With regard to the bovine form of the disease it cannot be doubted that its very conspicuous lesions must have been observed from early times on, but no clear descriptions were left by the ancients.

The first scientific mention of the disease was made in the seventeenth and the beginning of the eighteenth centuries, and then it was regarded as a venereal affection and spoken of as the " Frenchman's disease."

After the fundamental studies of Laennec an intelligent comparison between the human and bovine forms of tuberculosis became possible and a period followed marked by warm controversies, pro and con, relating to the identity of the two diseases.

This was, however, the same period during which the researches originated which mark the nineteenth century as the most prolific for the advancement of knowledge thru the general and logical application of experimental inquiry. It was the age of Pasteur and his momentous discoveries regarding the true nature of the communicable diseases, and one of his contemporaries, Villemin, in the year 1865, practically settled all further controversy by the demonstration of the transmissibility of tuberculosis in all its forms by animal inoculations.

Villemin's discovery ushered in the modern period considering tuberculosis as an infectious disease.

This work was brilliantly completed in 1882 by Koch, who at that time made known his discovery of the germ of the disease, which he isolated, cultivated, and demonstrated to be constantly present in the lesions. The cause of tuberculosis and its nature had thus become definitely known.

Another discovery of the greatest importance was that of tuberculin by Koch in 1890. As will be described further in this text, it supplied the means by which the presence of the infection could be made manifest long before the animals involved showed any signs of it. Tuberculin became the foundation upon which methods of control and eradication could be safely built.

The three discoveries mentioned supplied the means of attacking the disease in man and animals by exact methods. They placed tuberculosis in the category of preventable diseases.

They also, on the other hand, were directly instrumental in showing to what a frightful extent tuberculosis had eaten its way into the human and animal populations.

Species affected.—With the more exact means of identification of the disease by the acquisition of a more accurate knowledge of its nature, it came to be recognized as affecting a considerable number of animal species.

Tuberculosis affects all species of domestic mammals altho with different degrees of intensity and frequency. Cattle and swine furnish the greatest number of cases. The disease is further encountered in the horse, sheep, and goat, but is relatively rare in those animals in our country. Dogs and cats are susceptible to it. It is described in the camel and the elephant, while many wild animals kept either in captivity

or in a state of semidomestication readily fall victims to the infection. The disease is a bane to menageries and zoological gardens.

Tuberculosis frequently causes ravages among the domesticated birds, and many wild species kept in captivity readily contract the disease.

Distribution.—Thru the traffic in animals and the improved methods of communication, tuberculosis has been widely scattered over the earth and has in consequence become more or less of a problem in all stock-raising countries.

BOVINE TUBERCULOSIS

Definition.—Bovine tuberculosis is a transmissible disease of neat cattle due to the presence and vital activities of a specific microparasite known as the *Bacillus tuberculosis.*

Geographic distribution.—As already stated, tuberculosis among cattle is distributed thruout the entire civilized world. The improved means of transportation and especially the commerce in breeding animals and dairy stock has scattered the disease far and wide over the globe.

The greater part of these animals originated in the breeding districts of western Europe, where the dense bovine population, combined with the age-old practice of close stabling, tended to establish conditions extremely favorable to the spread of the disease.

The distribution of tuberculosis-infected animals to the various newly settled areas of the world took place, for a large part, during the period when the great economic importance of the disease was not yet fully realized, and before the time when it became possible to challenge their freedom from infection by the refined methods of a later day.

If the discoveries of Villemin and Koch had been made half a century earlier the bovine tuberculosis map of the world would now be quite different and this country for one could have been spared the serious losses occasioned by the disease and the necessity of dealing with it as a more or less vexing problem.

Morbidity.—Since the nature of bovine tuberculosis has become more thoroly understood, the disease has ceased to be a purely veterinary problem.

Its relation to a national food supply, to the success and progress of animal husbandry and to the public health, has also made it a subject of interest to economists and to statesmen in all countries where the population derives a considerable share of its sustenance from animal foodstuffs and especially in those countries where the promotion of agriculture

and the protection of the public wealth and health have come to be matters of governmental concern.

It is especially on account of those public phases of the problem presented by bovine tuberculosis that a brief examination of its morbidity rate is warranted.

While the disease had certainly acquired a foothold among the cattle of various regions of western Europe prior to the year 1800, there is reason to believe that a thoro infiltration of the infection took place principally in the course of the nineteenth century. During that period a marked increase in the population took place and concurrently agriculture and animal husbandry enjoyed a remarkable development, in the course of which the number of cattle increased in an unprecedented manner. The resulting density of the bovine population, combined with the practice of keeping cattle for a considerable part of the year confined in stables, established conditions particularly favorable to the spread of tuberculosis.

Nor must it be forgotten that during the greater part of the century disease was not opposed by rational methods of control. The great animal scourges breaking away from the plains of Asia from time to time overran Europe practically unchallenged and the nature and importance of tuberculosis was as yet unsuspected by the majority of the people.

The labors of Pasteur and those who followed the paths blazed by him had not yet borne fruit, but when finally, during the last quarter of the century, practical disease prevention could be undertaken with some prospect of success as a result of the advances made by science, it was found that tuberculosis, insidiously and yet assiduously spreading for several generations, presented a problem of such magnitude that to this day a practicable means of its ultimate solution has not been found in most of the European countries.

No doubt there are other important factors responsible for this unhappy state of affairs, but it cannot be questioned that the great prevalence of the disease is the principal obstacle to its conquest in those regions.

The statistical data from which the morbidity rate of bovine tuberculosis in western Europe can be compiled are by no means complete or exact, yet a fairly accurate estimate of its prevalence can be made when the returns of the various meat inspection services and the results of rather extensive tuberculin testing are subjected to a careful examination.

To a large extent those data reflect a situation which may come about in any country or state with a heavy or growing cattle population if an initial tuberculous infection is allowed to gain headway. For this reason the morbidity rates of a

few European countries, here submitted, may be of interest to our cattle raisers.

Great Britain.—Altho comprehensive statistics are not available, there is no lack of indications that the disease is quite prevalent in the United Kingdom. During the campaign against contagious pleuropneumonia in 1892, when many animals had to be slaughtered, it was found that from 20 to 30 per cent of the animals involved were tuberculous.

Tuberculin tests made from 1897 to 1899 in 15,392 animals were followed by positive reactions in 26 per cent of the cattle involved. In the dairies about Edinburgh 40 per cent of the cattle reacted positively and in those near London 23 per cent positive reactions were obtained. In the vicinity of Birmingham 38 per cent of the cattle were regarded as infected. At the Aldgate abattoir tuberculosis was found in 33.7 per cent of the cows. It has been estimated that approximately 30 per cent of British cattle are tuberculous. Probably these figures pertain to adult animals only.

Belgium.—In the course of a general tuberculin test in 1896, when 19,004 head of cattle were tested on 2,905 farms, it was found that 48.8 per cent of the animals yielded a positive reaction. On another occasion a test carried out on 149 farms with 2,805 head of cattle revealed 52 per cent of the animals as being infected.

Netherlands.—This country with its enormous cattle population shows high morbidity rates for bovine tuberculosis. Abattoir returns for 1914 showed 23 per cent of the animals slaughtered to be tuberculous.

Reports for 1917 show that in the sections where the dairy industry flourished the most, 30 per cent of the cattle were tuberculous. Among the cattle of 18 herds officially examined the morbidity rate reached between 8.3 and 57.7 per cent while the meat inspection returns for that year indicate that from 5 to 25 per cent of the animals were tuberculous, according to the locality in which the abattoirs were stationed.

Abattoir statistics for 1918 show a range of from 1.2 per cent to 35.9 per cent for the various establishments. In one dairy section, tests made in 243 animals yielded 58 per cent positive, 7 per cent doubtful, and only 35 per cent negative reactions.

In the reports for 1919, mention is made of the result of tuberculin tests made among the cattle contributory to a cooperative creamery. Of these cattle 20.7 per cent reacted positively, but it was found that of the 40 farms on which the cattle belonged only 5 were free from infection.

The cattle slaughtered during that year under official supervision showed from 5.12 to 38.9 per cent to be affected with tuberculosis, according to the location of the various abattoirs.

For the year 1920 the morbidity rate ranged between 2.64 and 41.9 per cent.

Denmark.—Bovine tuberculosis appears not to have existed in this country toward the end of the eighteenth century. During the following century it was introduced by cattle imported from Sleswick, Switzerland, and England. Since 1893, attempts at its control have been made and between that year and 1908 not less than 503,897 animals, divided over 19,717 farms, were tested. Of the animals tested, 21.5 per cent were found to be tuberculous, while infected premises ranged from 40 to 85 per cent of the total examined during a given year.

A series of tests reported by Bang showed the following results for the various ages of the animals tested: 38.6 per cent of the 5,047 animals from 1½ to 2½ years, 44.9 per cent of the 10,350 animals from 2½ to 5 years, and 48 per cent of the 11,924 animals which were older than 5 years, reacted positively.

Norway.—Tuberculin tests have been practiced since 1895, the positive reactions ranging between 3.2 and 8.4 per cent of the total number of animals tested during the various years. The average for all the years and for the 346,800 animals tested was 5.5 per cent. The infected premises, 26.1 per cent of the total in 1895, were reduced to 13.2 per cent in 1916.

Sweden.—In this country, of the 306,372 animals tested during the period 1897-1908, 29.8 per cent yielded positive evidence of tuberculosis, and more than 56 per cent of the 12,720 premises examined were found to harbor the infection.

Germany.—The distribution of bovine tuberculosis in Germany differs in the various parts of the country but the average morbidity amounts to about 25 per cent of all animals.

Meat inspection data indicate the following amounts for animals condemned on account of tuberculosis:

	Per cent		*Per cent*
1904	17.98	1914	23.41
1906	20.66	1916	19.04
1908	20.88	1918	15.01
1910	23.42		

The following table reflects the sectional distribution of the disease, also expressed in the percentage of carcasses condemned by the meat inspection service:

Year	Bavaria	Prussia	Saxony
	Per cent	*Per cent*	*Per cent*
1898	5.7	16.09	30.46
1902	6.8	16.40	30.98
1906	10.31	23.40	37.76
1908	11.92	22.73	37.85
1910	14.03	23.42	41.37

Switzerland.—In the majority of the cantons the morbidity rates are high. While the abattoir statistics place the amount of tuberculous animals at 19 per cent of the cattle slaughtered, tuberculin tests revealed the infection of 40 to 50 per cent of the animals tested.

According to Guillebeau the following morbidity was shown in the canton Zürich for the period 1898-1900:

Classes of cattle	Age	Per cent of tuberculosis
Calves	3 to 6 months	14.7
Young cattle	½ to 1 year	17.2
Young cattle	Over 1 year	21.5
Cows	Less than 4 years	28.7
Cows	4 to 7 years	35.9
Cows	Over 7 years	50.7

France.—Calmette estimates that in a total of 12,757,720 cattle for the year 1920 not less than two million animals were affected with tuberculosis. In those departments where dairy cattle are maintained under conditions of permanent stabling, the proportion of animals reacting to the tuberculin test surpasses 40 per cent. On the other hand, in the breeding districts where the animals are kept at pasture during the

greater part of the year the infection involves from 16 to 30 per cent of the cattle tested.

An inquiry made during 1910, covering the entire territory of the republic, showed an average of positive tuberculin reactors of about 16.5 per cent of the animals tested. However, in many localities near the larger cities the positive reactions amount to from 65 to 80 and even 90 per cent.

In the district from which the city of Paris draws its milk supply, tuberculin tests made between 1904 and 1921 showed a percentage of positive reactors ranging between 21.2 and 41.75 per cent.

The statistical data cited above are sufficient to show the extent of the disease in that part of the world where it has been able to spread for the greatest length of time without being opposed by determined efforts of control. From parts of this territory the cattle of the newer countries and colonies in other regions of the world originated and from there also the breeding stock required for the improvement of the cattle of the older and more remote nations was largely selected.

It is not surprising that the infection was scattered to all parts of the globe and that this spread of tuberculosis was particularly great when consideration is given to the fact that the movement of Old World cattle to newer regions was especially active at a time when the great importance of the disease and its powers for mischief were not yet fully recognized and when the international traffic in cattle was not yet subjected to adequate sanitary control.

Yet in spite of the facilities for introduction the disease has in only relatively restricted portions of the newer countries reached a degree of infiltration which can be compared to that seen in western Europe. This favorable aspect of the case is to be ascribed to the fact that in the newer countries the cattle population for a long time remained thinly scattered over large areas and either permanently remained at pasture and on the open range or did so for the greater part of the year. When the density of the cattle population increased and when stabling became more generally practiced, conditions for the spread of tuberculosis became more favorable and the disease here and there began to assume its Old World proportions.

The bovine tuberculosis situation on the North American continent is fairly representative of that which prevails wherever newer regions were invaded during the pioneer stages of agricultural development and where in consequence the initial progress of the infection was rather slow.

On the whole, the morbidity rate on this continent indicates

that the disease can as yet be successfully suppressed or eradicated even if there are areas in which European conditions are closely approached and where the solution of the tuberculosis problem will require no small amount of wealth and effort.

United States.—Since the coöperative and tuberculosis free area eradication plan was begun in 1917, rather comprehensive statistical information about the extent of bovine tuberculosis in the United States has become available.

The following data are all derived from publications and reports issued by the U. S. Department of Agriculture.

The following table compiled from the data mentioned not only conveys a fairly accurate estimate regarding the morbidity rate of bovine tuberculosis in this country but likewise indicates the growth of cooperative eradication work:

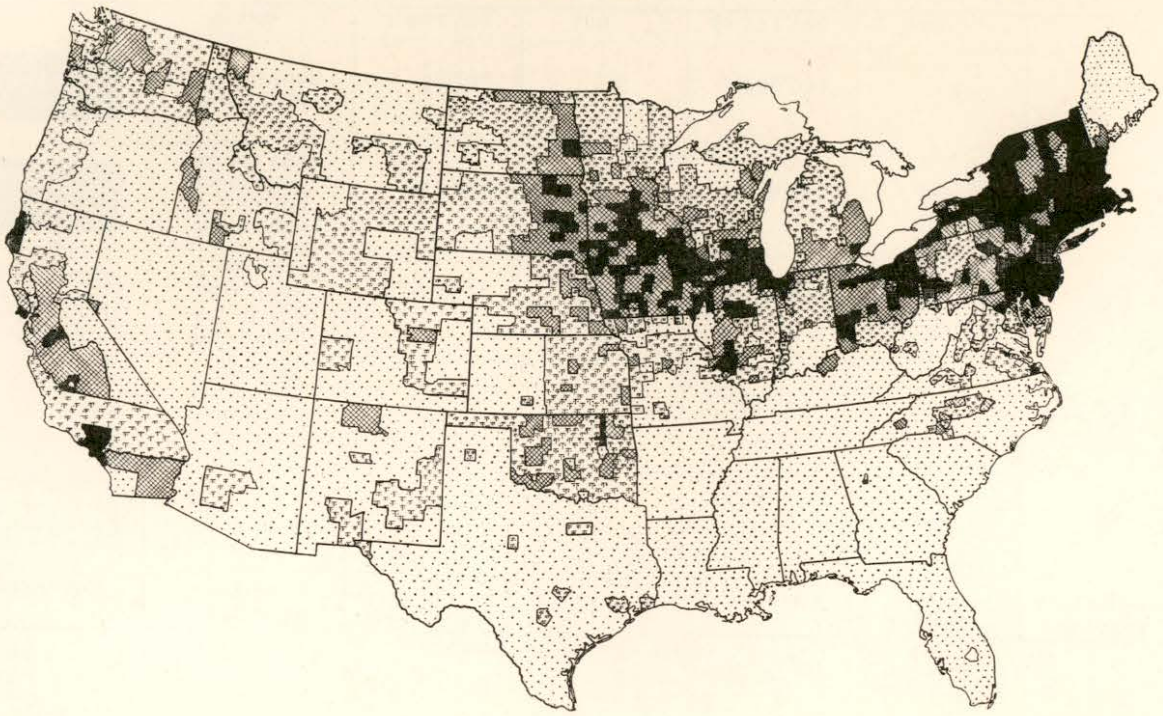
Fiscal year	Herds tested	Cattle tested	Reactors found	
			Number	*Per cent*
1917	.....	20,101	645	3.2
1918	.....	134,143	6,544	4.9
1919	.....	329,878	13,528	4.1
1920	40,348	700,670	28,709	4.1
1921	86,687	1,366,358	53,768	3.9
1922	195,220	2,384,236	82,569	3.5
1923	296,138	3,460,849	113,844	3.3
1924	455,034	5,312,364	171,559	3.2
1925	607,345	7,000,028	214,491	3.1
1926	774,728	8,650,780	323,084	3.7
1927	871,561	9,700,176	285,361	2.9
1928	1,048,277	11,281,490	262,113	2.3
Total	4,375,338	50,341,073	1,556,215	3.1

A comparison of the morbidity rates of the various states is made possible by a study of the following table representing the results of tests made during 1928. This table includes records of tuberculin testing done under the area plan.

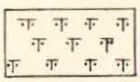
State	Herds tested	Cattle tested	Reactors found	Percentage of reactors	Infected premises
Alabama	3,329	57,968	90	1.6	53
Arizona	5,145	49,914	539	1.1	271
Arkansas	2,663	17,065	47	0.3	32
California	3,153	108,757	1,120	1.0	389
Colorado	1,144	18,273	328	1.8	221
Connecticut	8,570	102,240	9,115	8.9	2,254
Delaware	2,304	23,963	1,402	5.8	455
District of Columbia	87	750	1	0.1	1
Florida	1,551	49,087	419	0.9	102
Georgia	7,681	50,932	314	0.6	117
Idaho	6,299	91,014	401	0.4	185
Illinois	102,095	978,198	17,055	1.7	8,318
Indiana	52,453	386,163	2,740	0.7	1,555
Iowa	63,545	981,315	22,425	2.3	9,216
Kansas	24,518	266,672	1,442	0.5	840
Kentucky	15,525	88,137	432	0.5	233
Louisiana	3,567	51,844	649	1.3	236
Maine	21,591	123,793	898	0.7	382
Maryland	15,262	152,451	8,654	5.7	2,710
Massachusetts	3,138	52,769	3,996	7.6	909
Michigan	61,599	547,921	9,578	1.7	5,148
Minnesota	67,044	1,244,963	26,254	2.1	11,861
Mississippi	6,181	38,282	141	0.4	24
Missouri	6,849	72,426	301	0.4	159
Montana	6,870	112,784	323	0.3	169
Nebraska	29,145	373,003	4,489	1.2	2,571
Nevada	821	17,290	155	0.9	78
New Hampshire	6,001	78,960	2,715	3.4	682
New Jersey	7,791	61,223	4,434	7.2	2,059
New Mexico	2,243	15,803	143	0.9	72
New York	72,426	839,089	53,414	6.4	12,782
North Carolina	26,323	91,249	217	0.2	166
North Dakota	14,644	236,219	2,212	0.9	1,125
Ohio	60,970	444,743	10,471	2.4	3,810
Oklahoma	447	17,444	86	0.5	31
Oregon	21,545	156,771	960	0.6	439
Pennsylvania	78,623	717,110	30,573	4.3	9,100
Rhode Island	474	99,138	1,311	14.3	274
South Carolina	21,355	62,016	95	0.2	66
South Dakota	6,620	127,716	1,708	1.3	858
Tennessee	14,367	89,491	186	0.2	109
Texas	2,176	29,772	719	2.4	400
Utah	14,419	89,453	758	0.8	642
Vermont	8,380	167,014	4,073	2.4	991
Virginia	15,950	93,197	788	0.8	385
Washington	20,213	184,904	9,433	5.1	1,859
West Virginia	17,070	74,197	414	0.6	257
Wisconsin	65,926	1,147,831	20,947	1.8	6,750
Wyoming	1,824	16,205	112	0.7	36
Hawaii	693	17,963	319	1.8	100
Alaska	81	798	19	2.4	2
Interstate	45,587	455,210	2,698	0.6	*
Total	1,048,277	11,281,490	262,113	2.3	91,484

* Figures are not available.

Fig. 1.—APPROXIMATE DISTRIBUTION OF BOVINE TUBERCULOSIS IN THE UNITED STATES ON MAY 1, 1922

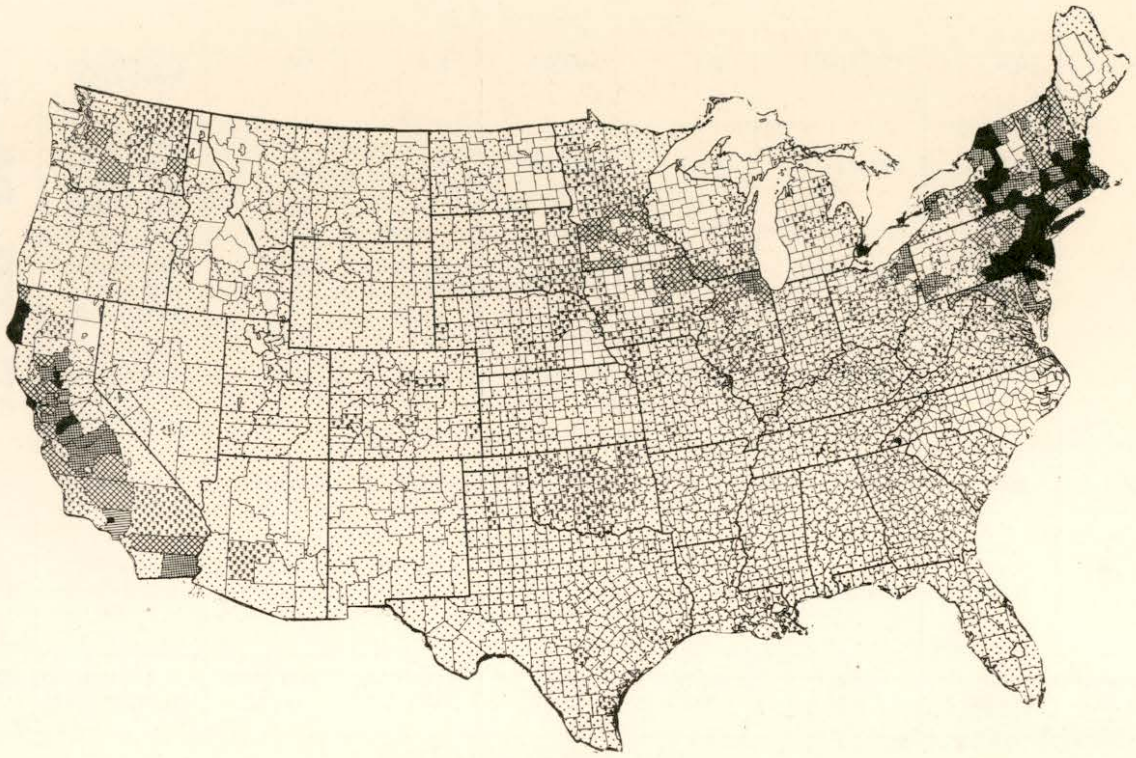


DESCRIPTION OF MAP (1922)

Distribution	Approximate extent	Total square miles	Per cent square miles	Total cattle	Per cent cattle	Per cent tuberculosis
	1 per cent or less.	1,673,616	46.4	28,338,254	41.2	0.6
	More than 1 and not more than 3 per cent.	780,856	21.7	17,484,566	25.4	2.1
	More than 3 and not more than 7 per cent.	952,664	26.4	12,397,445	18.1	4.9
	More than 7 and not more than 15 per cent.	143,827	4.	7,590,487	11.	10.4
	More than 15 per cent.	53,793	1.5	2,960,954	4.3	26.0
	Totals	3,604,702	100.	68,771,706	100.	4.0

(Map compiled from data supplied by Bureau of Animal Industry, U. S. Department of Agriculture.)

Fig. 2.—THE EXTENT OF BOVINE TUBERCULOSIS IN THE UNITED STATES MAY 1, 1928



DESCRIPTION OF MAP (1928)

Distribution	Approximate extent	Total counties	Per cent counties	Total sq. miles	Per cent sq. miles	Total cattle*	Per cent cattle	Per cent tuberculosis
	Modified accredited area.	499	16.2	373,178	12.6	9,759,449	15.9	0.3
	1 per cent or less.	1,959	63.8	2,094,432	70.5	34,736,585	56.4	0.5
	More than 1 and not more than 3 per cent.	354	11.5	290,510	9.8	9,593,593	15.6	2.0
	More than 3 and not more than 7 per cent	121	3.9	107,056	3.6	3,999,515	6.5	4.8
	More than 7 and not more than 15 per cent.	70	2.3	59,427	2.0	1,771,256	2.9	11.6
	More than 15 per cent.	69	2.3	45,007	1.5	1,696,681	2.7	26.4
	Totals	3,072 & D. C.	100.0	2,969,610	100.0	61,557,079*	100.0	2.0

* Note: Bureau of Census 1925 figures.

Nebraska.—The extent of bovine tuberculosis in this state as revealed by the results of testing undertaken as part of coöperative eradication work varies in the different localities.

RESULTS OF INITIAL TUBERCULIN TEST OF CATTLE IN NEBRASKA COUNTIES

County	Tested		Cattle reacted		Herds infected	
	Herds	Cattle	Number	Per cent	Number	Per cent
Adams	815	8,622	230	2.66	109	13.37
Boone	2,151	30,671	865	2.82	409	19.01
Buffalo	286	5,147	220	4.17	71	24.40
*Burt	1,662	20,475	350	1.71	197	11.85
*Butler	2,075	25,664	214	.83	121	5.83
*Cass	2,134	24,685	210	.85	110	5.15
Clay	1,473	14,339	526	3.60	348	23.00
*Colfax	1,514	27,434	425	1.54	210	13.80
Dawson	2,453	51,757	1,133	2.19	507	20.66
*Dakota	827	9,235	156	1.68	91	11.00
Dixon	1,490	18,964	260	1.37	135	9.06
*Dodge	1,913	30,616	543	1.77	230	12.02
Douglas	752	7,155	418	5.80	187	24.70
*Fillmore	2,009	19,583	125	.63	98	4.87
*Gage	3,004	36,604	139	.38	76	2.52
*Gosper	815	17,230	286	1.65	163	20.00
*Hall	1,700	25,760	484	1.88	249	14.64
*Hitchcock	913	16,738	78	.466	67	7.338
*Jefferson	1,833	23,119	166	.718	116	6.32
*Johnson	1,405	16,231	64	.39	35	2.49
Kearney	1,348	14,028	183	1.30	82	6.08
*Lancaster	3,408	42,231	340	.805	198	5.80
Madison	551	8,901	205	2.29	106	19.20
*Nemaha	1,638	15,968	169	1.05	110	6.71
*Otoe	2,264	29,527	96	.32	80	3.52
*Pawnee	1,577	21,611	107	.495	73	4.62
*Perkins	843	14,145	322	2.276	175	20.759
*Phelps	1,286	21,768	123	.565	105	8.16
*Polk	1,643	20,848	263	1.27	118	7.18
*Red Willow	1,219	22,703	148	.65	86	7.05
*Richardson	2,187	23,576	49	.208	35	1.60
*Saline	2,130	20,759	209	1.006	166	7.79
Sarpy	509	3,778	173	4.5	78	13.3
*Saunders	2,530	30,560	532	1.74	266	10.50
*Seward	2,206	28,813	239	1.004	174	7.919
*Thayer	1,928	25,736	74	.287	42	2.17
*Thurston	1,114	11,947	175	1.45	93	8.34
Washington	1,243	17,266	775	4.5	348	27.90
*Wayne	1,513	22,537	465	2.06	262	17.31
*York	2,113	21,378	467	2.18	290	13.72
Total	64,474	848,109	12,006	1.41	6,416	9.9

* Testing completed in counties so marked placed said counties on accredited list.

Cause.—Tuberculosis of cattle as well as that of all other animal species is caused by the presence, growth, and multiplication within the tissues and organs of the body of a specific germ, commonly designated as the *Bacillus tuberculosis.*

This organism occurs in the shape of straight or slightly curved rods, which may vary in length and thickness. Usually the length varies between one twelve-thousandth and one five-thousandth of an inch and in thickness between one seventy-five-thousandth and one fifty-thousandth of an inch.

The ends of these microscopic rods are somewhat rounded and their substance has frequently a more or less beaded appearance. The germ is not endowed with the power of motion and it is not capable of forming spores.

In the tuberculous tissues it is always present, altho in variable numbers. Sometimes it can be readily shown to be present in great quantity, and then again the number is so small that it can be demonstrated by special methods only. In the body and body discharges it occurs either singly or united in groups in which the bacilli are apt to lie side by side.

The bacillus of tuberculosis is not readily stained by the methods commonly in use. Special methods are required for the purpose, but when this is once accomplished the organisms retain the dye with the greatest tenacity. This feature is taken advantage of in order to differentiate this bacillus from other bacteria when tissues and discharges are to be examined for its presence.

The tuberculosis germ can be grown on artificial culture media but it always grows very slowly and especially so immediately after its isolation from the animal body and before it has adapted itself to the new conditions. It grows best at the temperature of the animal body and in the presence of air.

The addition of a small amount of glycerin to the culture medium materially promotes its growth.

After this growth has attained a certain age it presents some features of marked character. On coagulated blood serum or on glycerin agar there appear, toward the end of the second week of growth, very small, dull, grayish-white, and dry granules. As the growth advances, the latter become surrounded by a lighter colored zone which becomes confluent with those in its vicinity until the whole surface is covered by a continuous layer, dry, wrinkled, rough, and loosely adherent to the surface. The organism presents the same features when grown on glycerin potato, but there it is inclined to be drier and more crumbly. Cultures on glycerin beef broth present at first a delicate film on the surface, but

this layer gradually thickens as the growth advances. When a maximum of growth has been reached, the thick layer becomes folded and corrugated and shows a tendency to extend itself on the side of the flask. The broth, however, remains clear thruout.

The bacillus of bovine tuberculosis is quite virulent for most mammals, among which the guinea pig is perhaps the most susceptible in spite of the fact that this animal is practically exempt from spontaneous infection. The guinea pig constitutes the most sensitive reagent to the bacillus and hence it has been commonly employed in the studies by which the nature of the disease was laid bare.

Outside the body of its host and when not kept in flasks as pure culture, the germ of tuberculosis does not multiply. It is an obligate parasite requiring narrowly circumscribed conditions for its propagation.

On the other hand, it shows a considerable power of resistance against many of the factors which are adverse to germ life.

Drying destroys the germ but slowly, and dried tuberculous material was found to be still virulent after from 102 to 180 days.

The bacilli contained in animal tissues were found to be alive after 167 days' burial in the soil, and cultures placed in water retained their virulence for 70 days. The germ remains alive in milk for 10 days, in sweet cream butter for 28 days, but in sour cream butter for only 10 to 15 days.

Direct sunlight is quite active in the destruction of tuberculous virus, and when present in a thin layer of transparent material it is rapidly destroyed when exposed to the sun's rays. The latter, however, are not very active on the virus when this is contained in anything but very thin layers or when the surrounding material is opaque. When kept in diffused sunlight the organism succumbs in from 5 to 7 days.

Low temperatures have no effect on it. Even a temperature of 350 degrees Fahrenheit below zero was not capable of killing the virus when the latter was exposed to it for periods ranging from a few hours to as much as 8 days.

On the other hand, the *Bacillus tuberculosis* is readily destroyed by heat. Boiling water or live steam completely sterilizes tuberculous material, either moist or dry, in from 5 to 15 minutes. When, however, dried tuberculous material is exposed to dry heat of the same temperature it requires an exposure of one hour before sterilization is complete.

Tuberculosis germs contained in milk are killed in one minute when heated to 150 degrees Fahrenheit in closed

vessels. When heated in open vessels an exposure of 6 minutes to a temperature of from 158 to 176 degrees Fahrenheit was not sufficient to destroy the virulence.

The salting and smoking of tuberculous meat has only a slight effect on the organism and tuberculous organs are occasionally found to be virulent after pickling for 6 weeks.

Disinfectants destroy the bacilli with a varying degree of speed but on the whole they are quite slow in their action and especially so when the germs are contained in tissues and excretions.

Carbolic acid in 5 per cent solution kills the bacillus in 5 minutes. The saponified cresols (liquor cresolis compound) have a similar action, while iodine and chlorine are more energetic. Corrosive sublimate and formaldehyde in solutions of one per cent kill in one hour. All those data, however, pertain to the action on cultures of the organism. When the latter is contained in the tissues, discharges, or stable filth the action of the disinfectant is much delayed and for many of them an exposure of from 2 to 24 hours would be necessary to make disinfection complete.

Virulent material.—When we speak of virulent material in connection with tuberculosis we generally have in mind any substance containing living tuberculosis bacilli capable of reproducing the disease when introduced into the body of a susceptible animal. The virulent materials represent thus the media in which the bacilli are contained. So far as the animal body is concerned, virulent materials may be classed in two principal groups. One of these consists of the fixed lesions of the disease and the other of substances which contain bacilli and which leave the body as excretions or secretions.

Tuberculosis in the majority of cases is a localized disease, which means that the body is not usually pervaded by the virus thruout, but that the latter is more or less confined in the lesions which characterize the disease. Bacilli are especially numerous in recent or young lesions and when the latter have become caseous or calcareous the number of germs present is commonly more or less reduced.

It would be a mistake, however, to suppose that the presence of bacilli in the body is necessarily always followed by the formation of lesions. In a small number of cases bacilli may be present without lesions or tubercles arising as a consequence. In such cases, the number of bacilli is usually small, altho the opposite is sometimes the case. Then we speak of the Yersin type of tuberculosis, after the investigator who first described this phenomenon. In cattle this lesion-

less form of the infection is most commonly seen in the case of animals reacting positively to the tuberculin test but in which no lesions can be disclosed by autopsy. It has been frequently shown that in such cases certain organs, while apparently normal, contained a variable number of bacilli.

Bacilli are likewise bound to be present from time to time in the lymph and bloodstreams.

There is reason to believe that as long as the lesions remain intact the bacilli are held imprisoned within them. When, however, the tubercles soften and tissue destruction takes place, the bacilli find their way into the various secretions and excretions and by them are conveyed out of the body. These substances constitute the virulent materials of the second group and owing to the part they play in the transmission of the disease they require special mention.

Of primary importance in this connection is the discharge which issues from the respiratory tract in cases of tuberculous lung disease. This must always be regarded as the principal means by which the germs of tuberculosis are eliminated from the body. Contained in the discharge mentioned, they may be directly cast out during coughing fits or by the slower discharge of mucus thru the nostrils.

This is, however, by no means the only avenue open to this virulent material for its escape from the body. In fact the greater part of respiratory discharge is neither coughed out nor expelled thru the nose but is swallowed by the animal concerned; and while the mucus and other matter which constitutes its bulk may be subsequently digested, the bacilli for a large part are not affected by the process and appear in the feces alive and fully virulent.

Owing to this feature, therefore, the manure of animals affected with lung tuberculosis must be looked upon as being of an infectious nature. Needless to say, in tuberculous disease of the intestines or the liver the same means of exit is open to the bacilli.

In tuberculosis of the kidneys and other portions of the urinary tract, the urine commonly is the vehicle which carries the bacilli on their outward journey.

The semen may serve the same purpose when the testicles harbor disintegrating lesions. In tuberculosis of the female reproductive organs the vaginal discharge is commonly virulent.

The milk must always be regarded as being infectious when udder tuberculosis is present; and even in cases of tuberculosis in other parts of the body, but with no appreciable udder lesions, the milk is frequently contaminated by the bacilli. It is this feature above all which has made the elim-

ination of the tuberculous milch cow an important factor in the protection of public health.

Vehicles of infection.—Only in a comparatively small number of cases is there a possibility that infected materials gain entrance to the bovine body in a direct manner, or, in other words, a direct transmission from animal to animal takes place only in exceptional cases.

As a general rule the virulent secretions and excretions find their way to some substance in the environment which may or may not be taken into the animal body.

Small droplets of mucus coughed out by an infected animal may remain suspended in the air for a brief period and in this situation be directly inhaled by some other animal in the immediate surroundings.

Or the infected droplets may settle on food or drinking water, to be taken in during the acts of eating and drinking. The nasal mucus in which bacilli are contained may soil eating and drinking utensils and from these be conveyed into another animal which takes its feed and water from them.

Infectious discharges from the bowels, the lungs, or other parts of the body, deposited in stables and subjected to a period of drying, may subsequently be ground to dust by passing feet and in that form become deposited on such substances as serve for food and drink. In this manner it is possible for the milk of sound cows to become contaminated thru the dust in stables where tuberculous animals are also kept.

Infected milk used for the feeding of calves and other livestock is a common means of a more or less direct transmission of the disease.

Modes of infection.—The animal body presents various portals thru which the infection of tuberculosis may be introduced. The most common of these are the respiratory and digestive tracts. Infective dust and droplets may be directly inhaled or be introduced into the pharynx, from which they can be readily passed into the digestive organs with the food.

Contaminated food and drink can introduce the bacilli directly into the intestinal canal, whence they are conveyed to other parts of the body thru the lymph and blood streams. Bacilli so introduced, entering into the substance of the intestinal wall, are apt to pass on without producing any lesions in those parts altho occasionally they become localized and cause tuberculosis of the structures concerned.

Other avenues of penetration, such as the genito-urinary tract, the eye, the skin, and the navel wound, while quite possible, are so uncommonly followed by the infection that they require but little consideration in connection with bovine tuberculosis.

At one time great weight was attached to so-called hereditary transmission in the propagation of tuberculosis. Since the acquisition of more exact knowledge regarding the cause of the disease this mode of transmission has been found to be of negligible importance. A communication of the disease to the fetus thru the original germ cells of either sire or dam has never been demonstrated in a manner in the least convincing.

On the other hand, transmission of tuberculosis to the fetus thru the placenta not only has been observed, but was actually proved by experimental methods. It appears to be very uncommon and it cannot be regarded as being of sufficient importance to be considered in any scheme pertaining to the prevention or eradication of the disease.

The rarity of congenital (so-called hereditary) tuberculosis is most clearly revealed by the small number of new-born calves found to be affected by the disease.

Nocard and Bang showed that 95 per cent of the calves born of tuberculous cows failed to react to the tuberculin test. Chaussé found only 4 cases of congenital infection among the 40 calves proved to be tuberculous among the 25,000 calves actually examined. This author estimates that of every 700 tuberculous cows there was only one which infected her offspring during pregnancy.

A multitude of observations have furthermore shown that calves, separated from their tuberculous dams immediately after birth, fed with milk from sound cows and kept away from all contact with infection, remain indefinitely free from the disease.

Predisposing factors.—While tuberculosis cannot come about without the presence and action of the specific bacillus, the fact must not be overlooked that there are certain circumstances and conditions which are particularly favorable to the infection and its spread, while others exercise a special influence in the opposite direction.

Unlike in certain of the more virulent diseases, the transmission of tuberculosis does not take place with marked readiness. Spontaneous tuberculosis requires either a more or less prolonged exposure to the infection or an invasion by an overpoweringly great number of bacilli for the establishment of the disease in the animal body.

The conditions which favor infection are associated with the environment in which animals live as well as with the condition of the animals themselves.

Among the former, the influence of the density of the cattle population can be credited to operate in favor of the

propagation of the disease. As in all other transmissible diseases, the tuberculosis incidence is apt to keep pace with the number of susceptible animals available in a given area unless the disease be opposed by adequate restrictive measures. As has already been pointed out, this factor has exercised a powerful influence on the distribution of the disease, and the bovine tuberculosis map of the world shows a marked parallelism with the one which depicts the degree of density of the cattle population.

Of equal importance to the propagation of tuberculosis is the practice of stabling animals during prolonged periods. In a general way it may be said that tuberculosis in both cattle and man is essentially an indoor disease or one which is most commonly contracted within the confines of buildings. It is doubtful if tuberculosis would ever have become the great incubus on man and animals that it is today, were it not for the fact that man and animals from early times on have been herded into houses and stables.

This feature is especially accountable for the enzootic and endemic character of tuberculosis in the more northern climes where winter housing is a necessity.

In stables and houses where infection is once introduced the concentration of virulent materials and the increased facilities for exposure cannot fail to promote infection and dissemination by and of the disease.

The infection risk is further increased by bad hygienic conditions, which not only favor the preservation of the virus, but also are apt to render the animals concerned more susceptible to its action.

Cattle on the open ranges are as a rule quite exempt from the disease, but there also it will in time assert itself when infected animals are introduced and means of contact are provided. Common watering troughs and shelters even under the highly favorable conditions mentioned are prone to become clearing houses for the transmission of the disease.

The animal body itself presents varying degrees of susceptibility at different times and certain animals become more readily infected than others. The normal animal tissues always have an inherent power of resistance to infection, but when this power becomes impaired they are not always capable of withstanding the onslaught of invading germs.

Mention has already been made of the ill effect of unhygienic housing and to this may be added the predisposing influence of undernourishment, of faulty body conformation, and of previous disease.

Heavy milking and the accompanying drain on the animal's vital resources must also be reckoned among the factors making for an increased susceptibility to tuberculosis. This factor is rendered even more potent of mischief by inadequate feeding and the lack of open air exercise. Age, likewise, appears to have a predisposing influence, altho this may be more apparent than real.

It is needless to point out that the opposite of the predisposing factors mentioned will tend to reduce the tuberculosis hazard correspondingly.

Lesions.—The formation of nonvascular cellular nodules or tubercles must be recognized as the most characteristic feature of tuberculosis.

These nodules are the result of local inflammatory processes set in motion by the presence and vital functions of the invading germs.

In this process the connective tissue elements of surrounding tissues as well as the cellular constituents of the capillary blood vessels proliferate and group themselves as a spherical mass. The cells composing this microscopic nodule take on an epithelium-like character and often contain one or more bacilli in their interior. Either by the nuclear division of those epithelioid cells or by the fusion of a number of them, large cells with many nuclei arranged in a peripheral position are formed and are quite a characteristic of tuberculous lesions. Such cells are known as giant cells.

The microscopic nodule soon becomes surrounded by a zone of small, round cells, leucocytes, which have migrated from the blood vessels of the immediate vicinity. These cells increase in number, penetrate between the epithelioid and giant cells and finally constitute the preponderating elements of the tubercle. At that stage the tubercle may be said to be fully developed and can be seen by the naked eye.

However, no sooner has this stage been reached than degenerative changes in the center of the tubercle become apparent. Owing to a lack of nutrition and to the presence of toxic substances produced by the bacilli, the central cells perish and their disintegration gives rise to the formation of a granular, cheesy material which at a later period may become infiltrated with lime salts, so that the structures involved become calcareous.

A fully developed tubercle appears as a nodule of the size of a millet seed, grayish in color, transparent, and in the bovine disease quite firmly adherent to the surrounding structures.

Even after the caseation has begun, it may increase in size by the further migration of cellular elements or it may

become fused with adjoining ones. As the process of caseation keeps pace with the development or fusion of the tubercles, a considerable amount of cheesy material may come about.

Masses of cheesy or calcareous material are commonly found to be surrounded by a more or less dense connective tissue capsule, an arrangement which tends to isolate the tuberculous focus from the remainder of the body.

The tubercle just described may be regarded as the fundamental unit of all tuberculous processes, but as one examines the various organs affected with the disease the appearances by which the latter expresses itself are not the same under all conditions.

This is the result of modifications arising from the structure of the organ affected, the location of the disease, or the avenues by which it was disseminated thruout the body. While all tuberculous lesions are thus essentially of the same nature, the variations in their aspects have led to the recognition of various types.

One of those is known as miliary tuberculosis, a name suggested by the fact that in this type a considerable number of small (millet seed sized) tubercles are scattered thruout one or more organs. This type of lesion indicates that bacilli were conveyed at one and the same time to the parts involved by means of the blood current.

When the organ involved has become changed into a voluminous, dense mass of light or chrome yellow color, we may speak of the lesion as being a cheesy or cheesy-calcareous infiltration. This type is commonly met with in cattle and especially so in association with affected lungs and lymph nodes.

Structures presenting this type of lesion may ultimately undergo softening by the breaking down of the tuberculous mass, and then cavities are formed.

Such cavities vary in size from that of a hazelnut to that of an orange or cocoanut. They are filled with a cheesy pus-like material in which a gritty substance may be found and are commonly provided with a wall composed of a dense, fibrous connective tissue. Cavities arising from the softening of tuberculous masses are more commonly found in human pulmonary tuberculosis than in the bovine disease.

Another type known as the fungoid granulomatous one may be observed when tubercles develop from a free, usually a serous surface. In such cases there is a progressive and luxuriant growth of nodules appearing as large nodular growths of a grayish white or grayish pink or yellowish pink color.

When the skin and mucous membranes become involved in tuberculosis the breaking down of the tubercles gives rise to surface damage and the formation of ulcers. The latter vary in size. The largest ones are apt to be found in the intestines and there they are commonly round and oblong in shape. Usually they are quite shallow and surrounded by a prominent wall of thickened mucous membrane. The ulcer surface has a roughened or granular appearance. In color the ulcer may range from a dirty red to yellow.

The lesions of bovine tuberculosis are variously distributed thruout the body. While such organs as the lymph nodes, the lungs, the serous membranes, the liver, the spleen, and the kidneys are the ones most commonly affected, no other organ or part is absolutely exempt even if in some (muscles, heart) lesions are extremely rare.

There is a common tendency for the lesions to be extended to other parts. This may come about by the mere continuity of tissues or by distribution of the infectious agents by the blood and lymph streams. In the former case the infection slowly invades the parts adjacent to the initial lesion. Lesion complexes thus arising are usually designated as local ones, while in the cases in which the bacilli are carried to the more remote parts of the body the term *generalized tuberculosis* frequently finds application and especially so when the blood stream has been responsible for the transportation of the organisms.

It is, however, not always possible to ascertain with any degree of exactness how the distribution of the lesions came about.

The various lymph nodes of the body are most frequently involved in the disease. These organs receive the lymph drained from the various regions of the body and with this fluid the bacilli enter the nodes and are there retained. To a large extent, therefore, the disease of the lymph nodes is of a secondary nature, altho primary infection is also common enough. The changes produced by tuberculous infection of the lymph nodes can be readily recognized. Even in its earlier stages the presence of yellow cheesy nodules attracts the attention of the observer. Later the caseation becomes more extensive and the older the infection the greater the destruction of the tissues concerned. The lymph nodes become gradually enlarged and become harder in consistency. Commonly the tuberculous mass becomes permeated with lime deposits and then assumes a mortar-like character, the mass gritting under the knife when incised.

The caseous masses found in these structures frequently have a sulphur or chrome yellow color not unlike the appear-

ance of the yolk of a hard-boiled egg. The tuberculous mass sometimes softens and the lymph node involved changes to a cavity filled with a semi-liquid, cheesy, gritty debris.

Certain groups of lymph nodes as a result of tuberculous infection are transformed into voluminous tumor-like masses which by their pressure on important structures or organs nearby may give rise to serious disturbance in the body functions.

In tuberculosis of the lungs, which is a most common localization of the disease in cattle, one finds the affected organ to contain lesions of variable sizes. They are commonly inclosed in a more or less well-developed fibrous connective tissue capsule. When incised they prove to be quite dense and display a yellowish or reddish gray caseous mass, usually dry and gritty. In other cases the softening of the tuberculous areas has progressed to the extent of liquefaction, giving rise to fluctuating cavities filled with a lumpy, thick, yellowish debris, resembling pus.

The lung itself is frequently distorted by the tuberculous masses and its surface is nodular in appearance.

In chronic miliary tuberculosis of the lung, numerous tubercles of various stages of development, single or conglomerate, are distributed thru the organ and when they are very numerous the latter is enlarged and indurated.

A common feature of bovine tuberculosis is the involvement of the serous membranes, such as the pleura, the peritoneum, and the pericardium. In those structures either the lesions may result from a primary infection or they may be secondary to disease of organs covered by the membranes mentioned.

The tubercles seen in connection with those structures commonly project from the free surface and give rise to two types of lesions, one characterized by the formation of small tubercles from a millet seed to a large pea in size and the other marked by the presence of large tuberous masses of a fungoid nature.

The tubercles protruding from the surface are round, ovoid, or somewhat flattened; at first small grayish white in color, they gradually become larger and then show a yellowish, cheesy center.

Their pearly appearance and conspicuous nature caused the name of "pearl disease" to be attached to this form of tuberculosis by the earlier writers on the subject.

As the surfaces of the membranes become thickly beset, the excrescences formed somewhat resemble bunches of grapes, which explains the name of "grapes" often applied to this disease by the butchers of previous generations.

The fungoid type of the serous lesions arises from the continued development of those masses and from their compression by the adjacent organs. Occasionally they assume a considerable size and often have a nodular, cauliflower-like appearance.

Tuberculous lesions are also associated with the digestive organs. In the tongue as well as in the walls of the pharynx cheesy nodules are sometimes observed. The stomach is but rarely affected, while the mucous membrane of the intestine may present either tubercles or tuberculous ulcerations.

The liver is commonly involved and the lesions of that organ are often of the miliary type scattered thruout and frequently of a uniform size. Large tuberculous conglomerations are also found consisting of cheesy or mortar-like masses ranging in size from that of a walnut to that of a man's fist. When the liver is gravely affected its tissues between the tuberculous masses gradually waste away and become replaced by a dense scar tissue.

In tuberculosis of the kidney, the tubercles are small when the disease is of recent origin. They are found scattered thruout the organ or are confined to one or more of its lobes. As the disease progresses the tubercles become larger and confluent and undergo the usual process of caseation. When they soften, cavities form which occasionally discharge their contents into the pelvis of the organ, whence it is conveyed outward by the urinary passages.

The reproductive organs of the male are rarely involved in tuberculosis. The testicles as well as the penis may present lesions of the usual characters.

In the female more frequently than in the male the disease affects the genital organs. The mucous membrane of the genital tract often shows both tubercles and ulcers, while commonly enough the uterus, tubes, and ovaries participate in the disease process associated with the peritoneum. In uterine tuberculosis the wall of the organ is thickened and permeated with tubercles of various sizes and in different stages of caseation. The tuberculous ovary is enlarged, hardened, nodular, and encloses tubercles with a cheesy or gritty content separated from the surrounding parts by a dense fibrous connective tissue.

The udder commonly participates in the disease and when the latter is well developed the organ presents several dense nodular masses, cheesy or calcareous in character and varying in size. The organ becomes dense and hard by the proliferation of the connective tissue elements.

Characteristic lesions are occasionally found in the spleen, bones and joints, subcutaneous connective tissue, the central nervous organs, and practically all other parts of the body.

Symptoms.—In the majority of cases of bovine tuberculosis, symptoms are either entirely lacking or so vague and obscure as to be of no material assistance in the recognition of the disease. In many cases characteristic symptoms are in default even if the disease has already involved important organs. It was this lack of symptoms which, until the discovery of tuberculin, made rational control and eradication so exceedingly difficult. The absence of definite symptoms is likewise responsible for the fact that the disease so often makes serious inroads into a herd of cattle without its presence being suspected by the owner.

As tuberculosis progressively involves the organs of the animal affected, signs of ill health are apt to make their appearance and as a rule they do so in a slow and insidious manner.

The symptoms presented by those more advanced cases as a rule pertain to disturbances in the functions of the organs which happen to be affected.

In tuberculosis of the lungs one of the first signs observed is a tendency on the part of the animal to cough. As a rule this cough is short, dry, and hacking and may not be observed to be constant in manner. It is commonly provoked when the animal leaves a warm stable and suddenly has to inhale the cold outside air.

Likewise it may be especially noted immediately after the animal begins to eat or drink or when it exerts itself or when suddenly brought in contact with dust or other impurities of the air.

Such animals may show shortness of breath, in the beginning only during exercise, but later also when they are completely at rest.

With the further advance of the disease and the extension of lung damage, the cough becomes more frequent and the hurried and short breathing denotes a considerable degree of respiratory distress.

In not a few of the cases the general condition of the animal becomes less thrifty; it no longer responds to good feeding and a loss of weight may be observed. The hair coat of such animals becomes dull and staring and they become hidebound. The appetite becomes capricious or fails, the visible mucous membranes become pale, and commonly the eyes sink more or less deeply into their sockets.

In the last stages of lung tuberculosis the wasting of the body tissues is often extreme; the body fat has disappeared

and the muscles of body and limbs have undergone a considerable reduction in size.

Such animals often stand with their heads extended and their elbows turned outward. When the animal is forced to move, the respiration becomes more difficult, and the cough, while still frequent, now becomes weak and painful and may be accompanied by a white, slimy, lumpy discharge from the nose. Commonly the animals so affected keep their mouths open and their tongues protruded.

Before the disease of the lungs has advanced to a degree noticeable in the living animal, other organs like the lymph nodes within the chest and the organs of digestion may have become involved to an extent sufficient to cause circulatory or digestive disturbances.

Changes in the body temperature may not be observed in the earlier phases of lung tuberculosis; but when the disease makes headway, fever is frequently observed, altho the behavior of the temperature offers nothing of a typical character.

In a small number of the cases the lining membranes of the air passages may participate in the disease of the lungs, but as a rule this is not expressed by characteristic symptoms.

Only in a considerable involvement of the larynx may the symptoms presented lead to the suspicion of tuberculosis.

In cases of this nature there usually is a spasmodic and painful cough, tenderness about the parts, and a roaring or snoring sound during respiration. Difficulty in swallowing sometimes accompanies this condition.

In lung tuberculosis the membrane lining the surface of the chest cavity and the outer surface of the lungs commonly shares in the infection.

The symptoms of pleural tuberculosis are usually very obscure. A cough is a common feature and pressure upon the chest wall frequently reveals tenderness. Striking the chest may cause the animal to cough, while in a number of the cases friction sounds may be heard when the ear is applied to the side.

The symptoms of tuberculosis of the digestive organs are even more vague than the ones presented by the animals suffering from the pulmonary form. Only when lesions are present in the regions of the mouth and throat may they be recognized by inspection. In intestinal tuberculosis digestive disturbances may be noticed. They ordinarily consist of constipation alternating with diarrhea, of periodic attacks of colic and bloating, and of lack of appetite. In the digestive

disease, the emaciation so typical of the disease is a frequent accompaniment of the disturbances mentioned.

Tuberculosis of the reproductive organs is not uncommon. It is rather frequent in the female as a feature of generalized tuberculosis. The ovaries are not infrequently found to be involved and the uterus is also apt to share in the disease process. In the latter case a chronic, purulent discharge composed of cheesy pus and streaked with blood may be found to be issuing from the external genital opening. Cows so affected are commonly sterile and during the earlier phase of the disease they may be continually in heat. The rectal examination of such animals is apt to reveal the organs involved to be enlarged and very dense to the touch.

Tuberculosis of the udder may be suspected when the organ presents hard, painless, ill-defined enlargement more commonly associated with one of the hind quarters, which gradually extends to the other parts of the udder and which slowly assumes the features of a large, very hard, and nodular mass.

The large lymphnode situated on the upper part of the hind quarter is commonly enlarged, hardened, and more or less nodular on its surface, a condition which should always lead to the suspicion of udder tuberculosis.

The male genital organs are but rarely involved in tuberculosis. The disease may be present in the testicles, which are then of nodular appearance and more or less indurated. In the penis the disease may manifest itself by the presence of small, hard nodules and shallow ulcerations.

Involvement of the lymphnodes is a regular feature in all forms of tuberculosis, and while in most cases this does not give rise to characteristic symptoms, occasionally such are present.

In appreciable disease of the superficial nodes they are hard, slightly tender to the touch and usually not adherent to the adjacent structures.

In some instances, as in tuberculosis of the lymph nodes of the throat, the swelling may be considerable enough to cause distortion of the parts and to interfere with the functions of adjoining organs by the exercise of pressure.

Tuberculous disease of the deeper lypmh nodes is, as a rule, not shown by any special signs unless their great volume causes them to encroach upon other organs. This complication may be observed when pressure by enlarged mediastinal lymph nodes upon the gullet or large blood vessels gives rise to disturbances in swallowing and rumination as well as in the blood circulation.

When the various symptoms mentioned are reviewed it is plain that while there is no lack of evidence that disease is

present it is not always possible to arrive at a definite conclusion by their consideration, as similar symptoms may also be expressive of conditions caused by diseases other than tuberculosis.

In order to recognize tuberculosis in the living animal, the mere symptoms are not sufficient, and more exact and accurate methods have to be depended on.

Diagnosis.—No doubt there are symptoms, such as a persistent cough, a general unthrifty, emaciated, or hidebound condition, constant oestrum in cows, shortness of breath, and the enlargement of certain superficial lymph nodes, which should cause one to suspect tuberculosis. However, most of these phenomena do not appear until the animal concerned may have become a dangerous infection spreader for a considerable period. Under such circumstances the disease, most frequently, escapes detection until the most opportune time for repressive measures has passed; and, no doubt, the many years during which tuberculosis could exist without being promptly recognized was an important contributory factor in enabling the disease to gain such a firm foothold in the herds of western Europe and of some sections of this continent.

The discovery of the specific bacillus was the first achievement, which inaugurated the possibility of challenging the further progress of the disease by preventive measures. But while definite and accurate diagnosis by the recognition of the bacilli in the excretions and secretions could thus be made, even this marked advance yielded no complete mastery over the situation. In the first place the collection of the materials suitable for the bacteriologic examination and the subsequent search for bacilli are tedious and often troublesome tasks which cannot obtain a wide application, and in the second place there are a great number of tuberculous animals which do not constantly throw off materials in which bacilli are present.

The problem of diagnosis thus remained only partially solved until the discovery of tuberculin, which eventually furnished the means of detecting the disease in even its most incipient stages.

Tuberculin. — Tuberculin, originally named Koch's lymph, after the great master who first prepared it in 1890, consists of a sterile extract of culture of the *Bacillus tuberculosis* grown on broth.

It is prepared as follows: The bacillus is grown for a period of from 2 to 3 months on a specially prepared broth containing 5 per cent of glycerin. When a suitable growth

has thus been obtained, the flasks containing the cultures are exposed to the heat of running steam for 2 hours, during which time the bacilli are killed and some of their component parts are extracted.

At the termination of the heating, the bacilli are separated from the broth by filtration. The clear fluid thus obtained, and which represents the original broth and such bacillary products as entered in the solution, is then placed on an evaporating bath and kept there until its volume is reduced to one-tenth of the original one. The liquid obtained at the termination of this process constitutes the concentrated tuberculin and presents itself as a brown, syrupy, limpid, clear fluid having the pleasant flavor or fruit-like odor characteristic of cultures of the tuberculosis germ.

The concentrated tuberculin forms the base of the various tuberculins used in the detection of the disease. Since the days of Koch several methods of tuberculin testing have been developed, but only those now most widely used in this country will be mentioned. They are the subcutaneous or thermic test, the intradermic or skin test, and the ophthalmic or eye test.

For the purpose of applying the subcutaneous test, a special tuberculin is prepared by mixing concentrated tuberculin with a one-half per cent solution of carbolic acid in such proportions that each 2 cubic centimeters of the resulting mixture contain from 300 to 500 milligrams of the concentrated tuberculin.

The test itself depends on the fact that normal animals which receive a subcutaneous injection of the tuberculin mixture mentioned continue to maintain their normal temperature and that tuberculous animals similarly injected after a definite length of time show a marked increase in the body temperature which maintains itself during a certain period and then gradually subsides.

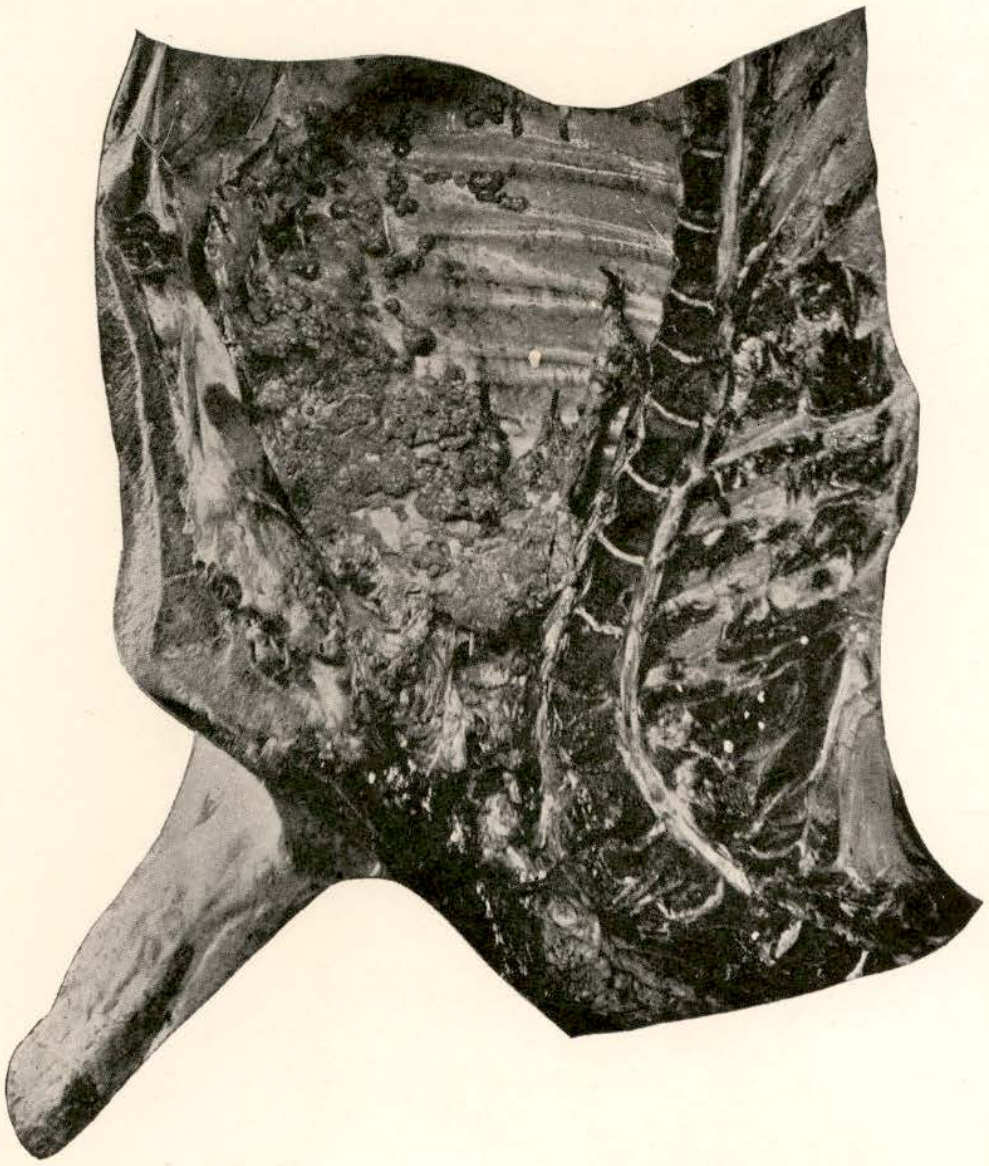
The subcutaneous tuberculin test in its practical application consists of certain phases which are here described.

The recording of the body temperature prior to the injection of the tuberculin in order to note the behavior of the temperature when not subjected to any interfering influences. This may be done by taking the rectal temperature by means of an ordinary fever thermometer in the morning and evening of the 2 days preceding the injection of tuberculin or by doing the same every 2 or 3 hours for one day. When the temperatures are taken, care must be exercised that the animals be quiet, free from excitement, and that they be not exposed to the excessive heat of the summer sun nor to the cooling effects of cold drinking water taken in consider-

able quantity. In the case of animals registering temperatures of 103° F. and above, the test should be postponed.

The injection of the tuberculin. The tuberculin is usually injected shortly after the last pre-injection temperature has been taken and recorded. It is made by means of a clean hypodermic syringe. The fluid may be injected under the skin of any part of the body, but ordinarily the side of the neck or the chest, just back of the shoulders, is selected for the purpose, because over those regions the skin is loose and thin.

PLATE 1



Half of a beef carcass showing extensive lesions of tuberculosis of the pleura. The lesions are of a chronic character. This represents the carcass of a dairy cow in fair condition.

PLATE 2

Half of a beef carcass showing extensive acute lesions of the pleura and peritoneum. This shows the carcass of a dairy cow in fair condition.

PLATE 3

A closer view of the carcass shown in Plate 2.

PLATE 4

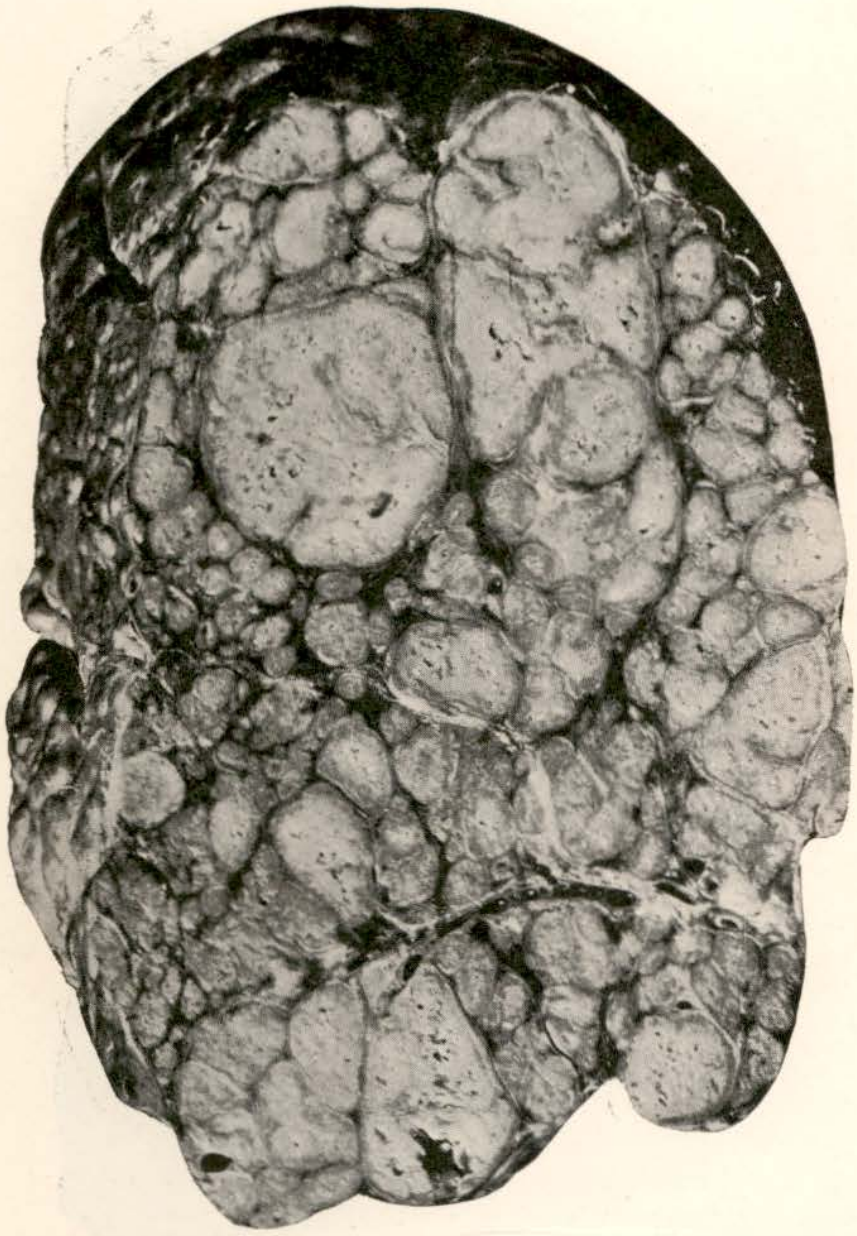
Liver of a cow affected with extensive tuberculosis, but otherwise in very good condition. (The wrinkled appearance of the surface is due to drying.)

Beef liver, showing extensive lesions of tuberculosis. This organ was taken from a steer carcass in very good condition, but affected with generalized tuberculosis.

PLATE 5

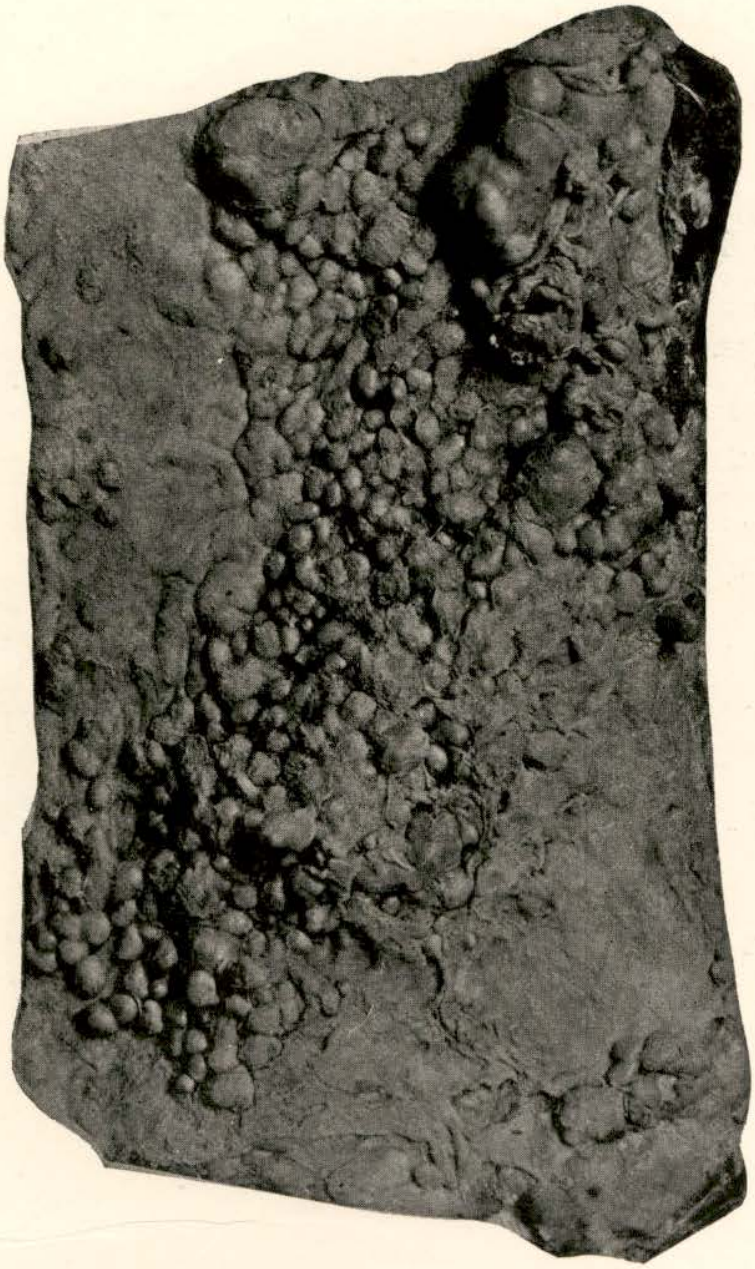
Beef lung and heart, showing extensive lesions of tuberculosis of both lungs, the pericardium and the mediastinal and bronchial lymph nodes. This lung was taken from a steer carcass in good condition although affected with generalized tuberculosis.

PLATE 6



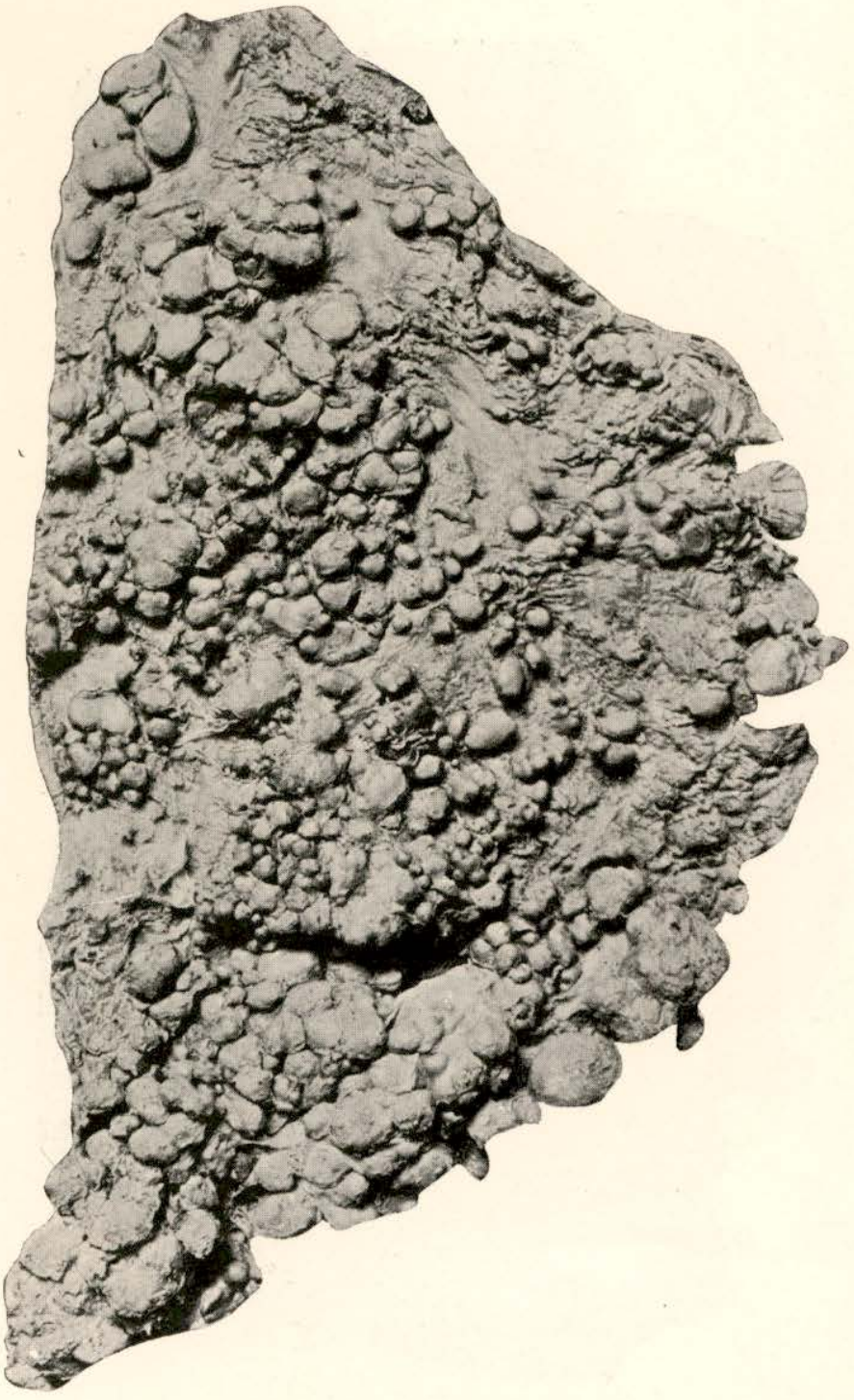
Section thru lung affected with chronic tuberculosis. The lesions are caseous and calcareous.

PLATE 7



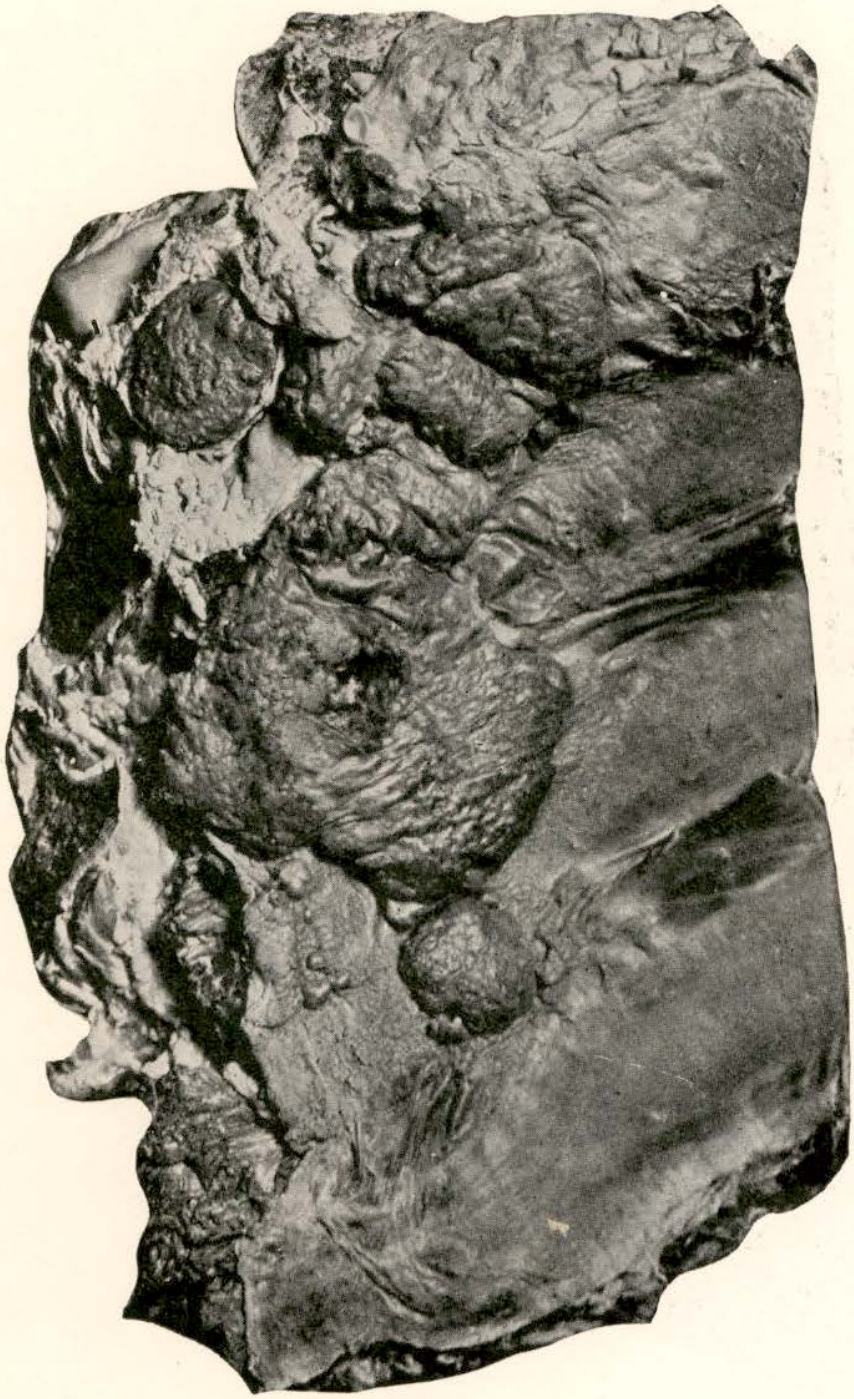
Tuberculosis of the pleura.

PLATE 8



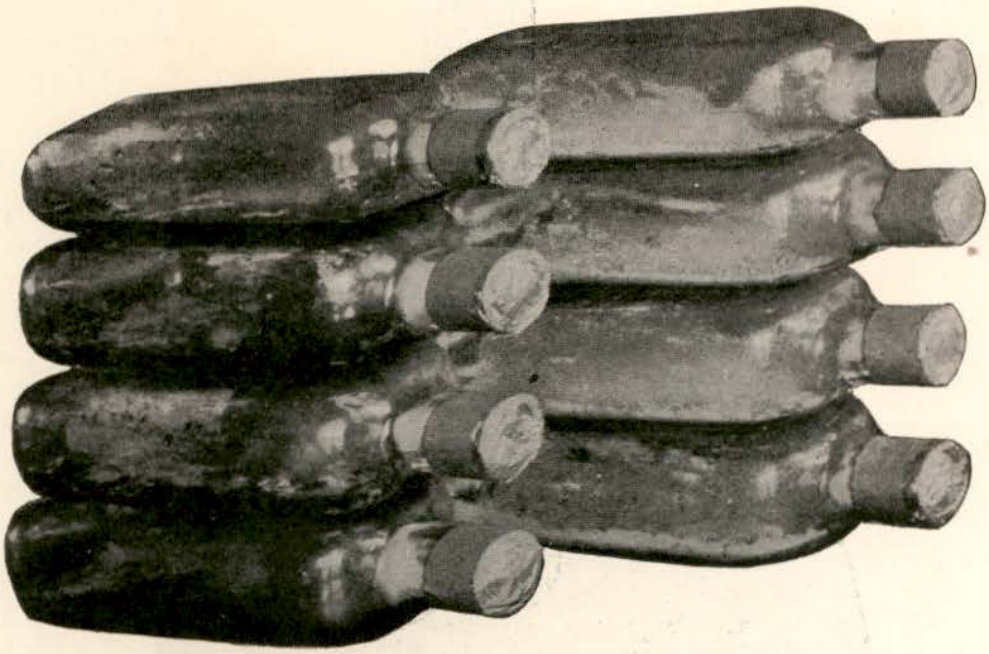
Tuberculosis of the peritoneum.

PLATE 9



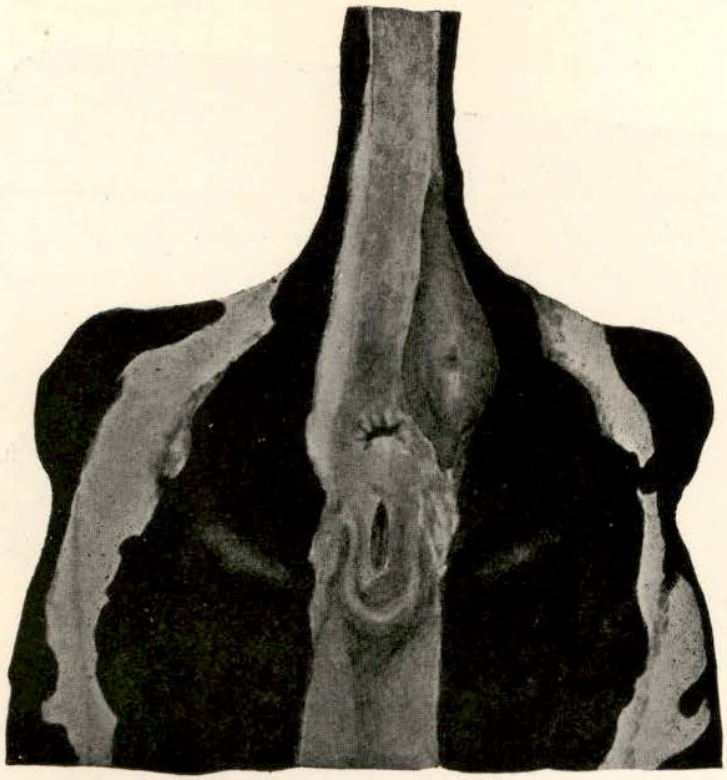
Tuberculous lesions of the fungoid type of the pleura.

PLATE 10



Cultures of the bovine tuberculosis bacillus, used in the manufacture of tuberculin. The flasks to the left were recently inoculated and those to the right contain old growths, ready to be killed.

PLATE 11



A positive local reaction following the intradermic injection with tuberculin in a tuberculous cow.

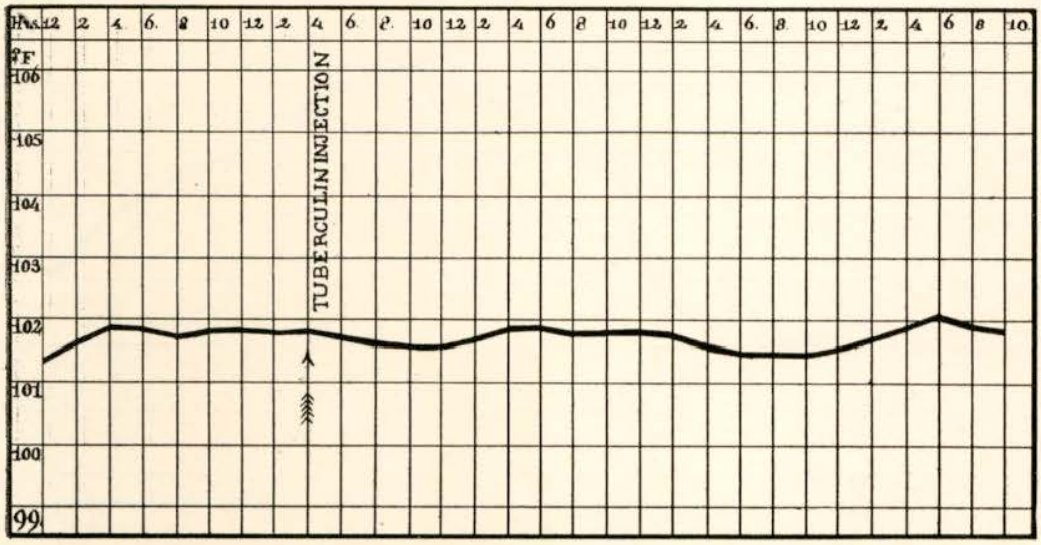


Fig. 3.—The pre- and post-injection temperature curve of a normal cow injected with tuberculin.

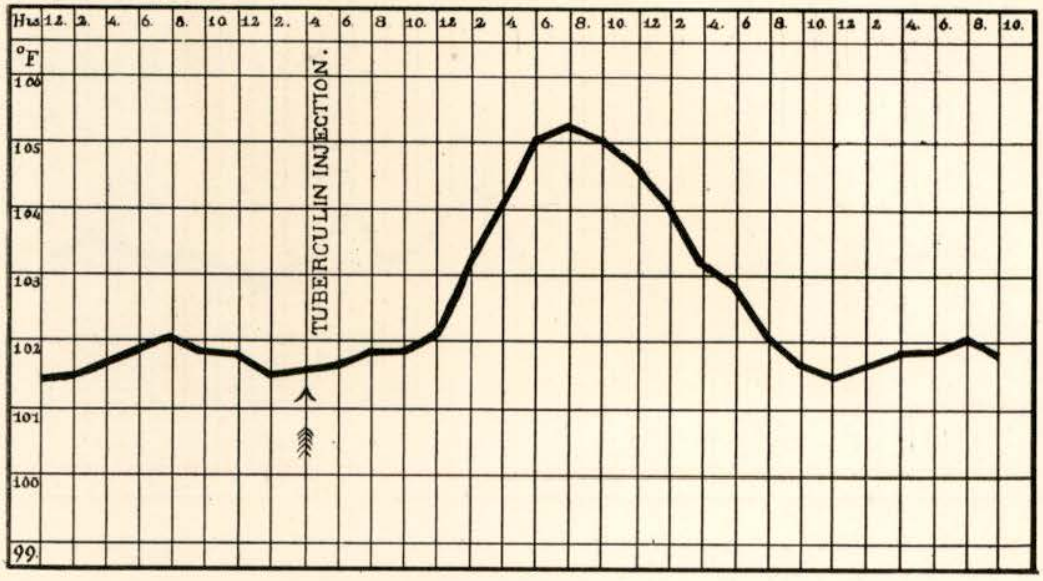


Fig. 4.—The pre- and post-injection temperature curve of a tuberculous cow injected with tuberculin. (A so-called "rainbow curve.")

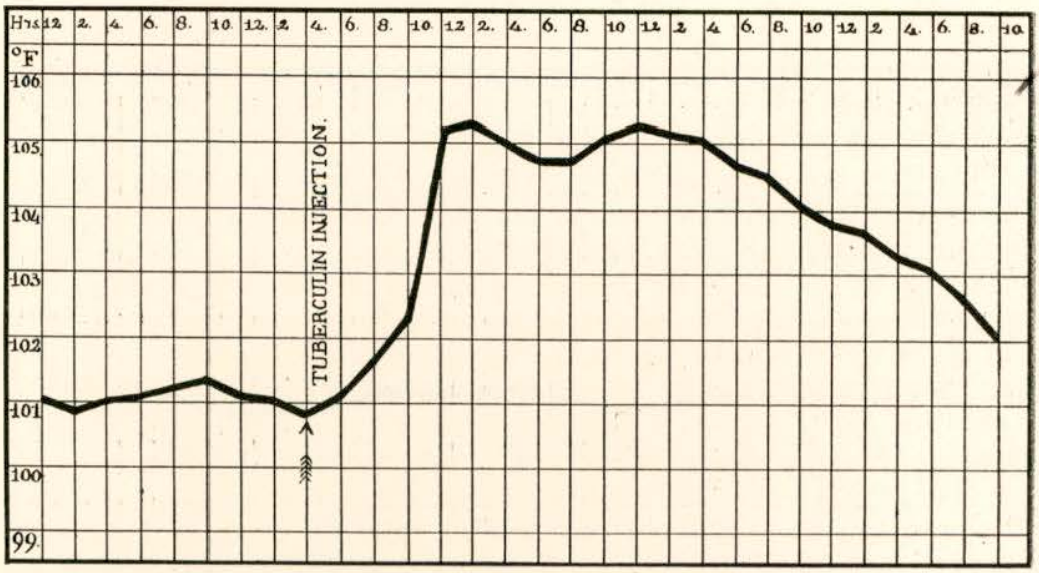


Fig. 5.—The pre- and post-injection temperature curve of a tuberculous cow injected with tuberculin. (A so-called "plateau curve.")

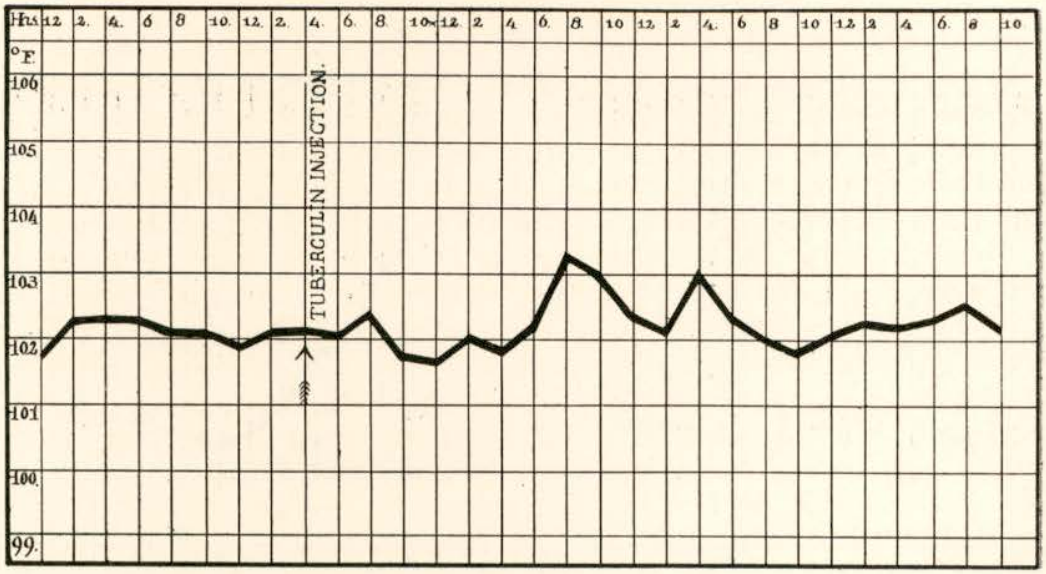


Fig. 6.—The pre- and post-injection temperature curve of a cow injected with tuberculin and showing a doubtful reaction.

Of the tuberculin prepared as indicated above the amount injected is 2 cubic centimeters.

The recording of the body temperatures after the injection of the tuberculin. This is done in the same manner as the preliminary temperatures were taken, with this difference, however, that beginning with the tenth hour after the tuberculin injection, the temperature is taken every 2 hours until 5 or 6 readings have thus been recorded.

The interpretation of the temperature records. After the temperature readings have been carefully recorded the results must be analyzed in order to determine the status of the tested animal with reference to tuberculosis.

The rise in temperature which follows the injection of tuberculin into a tuberculous animal constitutes the so-called thermic reaction.

This reaction usually begins from 6 to 10 hours after the injection, reaches its greatest elevation between the twelfth and twentieth hours, and then gradually declines to the pre-injection level, which is ordinarily again reached in from 24 to 40 hours.

In a certain proportion of the cases with well-marked thermic reactions, the latter are accompanied by dullness, loss of appetite, or a reduction in the flow of milk. Like the temperature reaction, such disturbances are of a temporary nature and soon disappear.

Many attempts have been made to determine with exactness what rise of temperature must be regarded as denoting the presence of tuberculous infection. It does not appear to be possible to draw hard and fast lines between a marked rise of temperature revealing infection and a more feeble one which may have some other origin.

The skill and experience in the interpretation of tests of the testing veterinarian must thus be regarded as an important factor in the correct classification of the animals tested.

Nocard, who was a noted authority on the subject, regarded a reaction as positive when the temperature rise amounted to 2.7° F. above the highest preliminary temperature recorded, while one amounting to from 1.4° F. to 2.5° F. should place the animal in the suspected class to be held for a second test.

Hutyra and Marek deem an animal more than 6 months old to be tuberculous when (a) its body temperature as compared with the highest pre-injection temperature is 2.7° F. or higher or amounts to 104° F. after a rise of not less than 0.9° F., or when (b) its temperature is 1.8° F. to 2.5° F. higher or amounts to more than 103.1° F. and at the same time is accompanied by systemic disturbances.

They hold, on the contrary, that there is no ground for the diagnosis of tuberculosis when the temperature has not increased more than 2.5° F. without exceeding 103.1° F. and is not accompanied by a systemic disturbance, provided that a thoro physical examination of the animal concerned does not reveal pathologic changes which may warrant the suspicion of tuberculosis.

In calves below the age of 6 months, they advise that only a rise of temperature to above 104.9° F. should be regarded as a positive reaction.

In this country the standards prescribed by the U. S. Bureau of Animal Industry are widely accepted. This method of interpretation provides that a rise of 2° F. or more above the maximum temperature observed prior to the injection of tuberculin or a temperature above 103.8° F. should be regarded as an indication of tuberculosis provided the temperature reaction shows the characteristic " rain-bow " curve. An elevation of temperature higher than 103.8° F. should also be regarded as an indication of tuberculosis even tho the so-called rainbow curve is replaced by one presenting what is called the " plateau " type. Animals which after the injection show a rise in temperature of 2° F. with a maximum of between 103° F. and 103.8° F. as well as those which show a rise of less than 2° F. with a maximum of 103.8° F. are regarded as suspicious. The presence of a general systemic reaction or of a typical curve should be considered in determining the classification between suspects and reactors.

When the American standard of interpretations finds application, the number of undetected tuberculous animals will probably be much smaller than after interpretation by the European standards mentioned. In the former case the possibility of a greater percentage of no-lesion reactors must be recognized while in the latter the risk of a greater percentage of non-reactors with lesions must not be overlooked.

It cannot be denied that in the interpretation of the recorded temperatures there is some risk of error associated with those forms of temperature behavior which occupy a position between the absolute absence of any reaction at all and the clean-cut and marked elevations indicating the presence of tuberculosis.

Practical experience, now involving millions of tests, reveals the fact that this margin of possible error is indeed a narrow one and that the preponderating number of temperature records permits a prompt and correct interpretation. The safest manner of dealing with the so-called doubtful reactions is to not interpret them at all and to depend upon the results of a second test to be made some time after the first one.

There is evidence which justifies the belief that doubtful reactions in herds with a considerable number of positive reactors should be regarded as indicating tuberculosis infection and that they can be looked upon as negative when they occur in herds in which no other animal presents a characteristic temperature rise. In the case of the latter instance,

however, isolation and retest of the doubtful reactor will always be the more prudent course to pursue.

A typically positive reaction indicates the presence of tuberculosis with a high degree of certainty. In the small number of reacting animals which present no lesions when the after-death examination is made, the apparent error is more apt to be due to the extreme sensitiveness of tuberculin than to its default, because it is capable of pointing out infection when the lesions are so minute as to escape observation even by the most skillful examiner. On the other hand, the reaction of such animals may be due to the presence of bacilli which have not given rise to lesions at all.

All tuberculin tests are merely qualitative in their indications. They will reveal the presence of tuberculosis infection but they will never give answer to the question: "How much is there of it?"

If the tuberculin test leads to errors in diagnosis at all, these do not so much pertain to the animals reacting positively but are more apt to occur among infected animals which failed to do so. It has been found that certain animals in the most advanced stages of the disease are no longer sensitive to the test. This source of error is, however, not very prolific of danger, because when animals are tuberculous to the extent of having lost their sensitiveness to tuberculin, they usually present signs by which the disease can be either identified or seriously suspected.

Another source of error is based upon the fact that certain animals, once injected with tuberculin, become for a number of weeks nonsensitive to a subsequent injection. Hence, when tests are to be repeated or when the test history of a given animal is unknown, it is wise to test only when it is certain that no tuberculin has been injected for a period of 60 days.

This peculiarity is responsible for the development of "plugging," the clandestine injecting of tuberculin by unscrupulous dealers, who thus make it for a while impossible for the presence of tuberculosis to be detected by the purchasers of the animals concerned.

It has been shown, however, that "plugged" animals also react but that they do so within a shorter space of time after the injection. "Plugged" animals can usually be detected when the post injection temperatures are begun to be taken 2 hours after a rather large dose of tuberculin has been injected.

The intradermic or skin test depends on another action of tuberculin which was discovered a number of years after the subcutaneous test had been thoroly established. It was,

namely, found that when a small quantity of tuberculin is injected in the substance of the skin (and not under it) of a tuberculous animal there arises several hours later at the point of inoculation a characteristic swelling, which does not follow when the injection is made in an animal that is free from tuberculous infection.

This test is now widely used and is apparently quite accurate in its indications and is particularly valuable when large numbers of animals have to be tested. It enables one operator to test a great number of cattle in a given length of time, can be applied to all kinds of animals without regard to age and disposition, and does not require owners to keep their animals confined for the greater part of a day. It has for these reasons also materially reduced the cost of tuberculin testing.

On the other hand, the successful application of this test demands a greater skill and more experience on the part of the veterinarian making the injections.

As a rule a more concentrated tuberculin is used in the intradermic test, while a much smaller quantity of it is injected than in the subcutaneous test.

By means of a small caliber needle mounted on a hypodermic syringe not more than 2 drops of the specially prepared intradermic tuberculin is injected in the skin, which prior to the operation has been cleansed by means of a pledget of cotton dipped in alcohol.

It does not matter greatly at what part of the body the injection is made, but practice has established the fact that one of the folds of skin which occur at either side and below the base of the tail is most suitable for the purpose.

No further notice is required to be taken of the animal in process of being tested until on or about the 72nd hour after injection. If reactions are found to occur in the herd tested, it is advisable to repeat the inspection on or about the 120th hour, and if it appears necessary another observation may be made on or about the 144th hour.

The swelling which indicates a positive reaction may appear as early as 6 hours after the injection, but usually it does not become plainly manifest until after from 12 to 24 hours. The enlargement increases in size for 2 or 3 days and frequently does not attain its maximum volume before the 72nd hour after the introduction of the tuberculin. It persists for 3 or 4 days longer and then gradually subsides.

The enlargements thus produced in tuberculous animals show considerable variations in size, ranging from that of a pea to that of an orange. They may be either quite dense and hard or soft and doughy to the touch. In some instances they are sharply defined; in others they are more diffused

in character. Commonly they are more or less painful and not rarely present evidence of inflammation. In a few cases the reaction is very intense and may lead to the formation of a superficial sloughing of a small area of the skin around the point of inoculation.

The presence of marked swellings should always be regarded as evidence of a positive reaction to the test; and, especially in herds which show infection, it will be wise to classify as positive reactions even the very small enlargements other than the sharply defined, shot-like nodules occasionally found at the point of inoculation.

In the interpretation of the intradermic tests the judgment, skill, and experience of the testing veterinarian will always remain an important factor in the successful detection of the disease.

In the ophthalmic or eye test for bovine tuberculosis use is made of a concentrated form of tuberculin or of small compressed discs composed of a precipitated tuberculin. This, instead of being injected under or in the skin, is simply inserted between the eyelids of one of the eyes in such a manner that it comes in general contact with the mucous membrane covering the eyeball and the eyelids.

When this is done in the case of a normal, healthy animal nothing of an unusual nature occurs, but when the animal so treated is infected with tuberculosis there appears in from 6 to 12 hours, and sometimes even later, after the instillation of the tuberculin, in connection with the eye concerned an inflammatory reaction manifested by a free flow of tears and by redness and swelling of the mucous membrane. After several hours these phenomena are followed by the appearance of a muco-purulent or purulent yellowish discharge which clings to the hair below the inner angle of the eye and which finally dries as a yellowish scab.

This test is especially recommended to be used in combination with any of the preceding ones wherever there appears to be good reason for doing so. In this country the eye test is but rarely used alone.

For the purpose of testing, the liquid tuberculin or a tuberculin disc is placed under the upper eyelid near the external angle of the eye. After this the hand is placed over the eyelid and the part massaged for a half minute or so in order to make certain that the tuberculin has been dissovled and distributed over the mucous membrane and is not lost thru the movement of the eyelid.

It is deemed advisable to make observations beginning with the second hour after the instillation and to continue doing so every 2 or 3 hours for not less than from 8 to 12 hours. Observation of a reaction is usually possible for a much longer

period, and owing to the fact that some animals in tuberculous herds react rather slowly it is advisable to continue occasional observations up to between the 12th and 24th hour.

In tuberculin a means has become available by which tuberculosis can be recognized with uncanny certainty in animals long before any physical evidence of the disease can manifest itself.

It has become the pivot upon which the machinery of tuberculosis prevention and control turns.

When Villemin proved the transmissibility of the disease and when Koch disclosed its cause they revealed a problem of the greatest magnitude and of the most perplexing nature; and when the latter scientist discovered tuberculin, he provided, so far as bovine tuberculosis is concerned, the tool which placed its solution within the range of possibility.

Forecast and treatment.—Careful inquiry into the course and final outcome of human tuberculosis shows that the disease is not irrevocably fatal when patients are properly treated and cared for and when such treatment is undertaken and continued faithfully before the damage has become too extensive.

It is not improbable that the same results would be attainable in bovine tuberculosis if there were no other considerations than the mere saving of lives or the restoration to a bearable state of health. Those other considerations, however, represent insurmountable obstacles to that type of management which might lead to the successful solution of the problem by anything in the nature of treatment of the affected animals or by any plan other than what is included in the term prevention.

Cattle tuberculosis is first of all a matter in which the items of profit and loss are dominant. The bovine animal is to be a producer of profit, without which it has no reason for further existence; and the length of its productive life is far too short to make good any outlay of time and money such as would be required to change a tuberculous animal to a sound one even if this could be done at all. The cost of isolation of all infected animals would be prohibitive and without such precaution there would be a great probability that the disease would be transmitted to other individuals and that the process of saving one animal would necessitate its repetition for a dozen others. Furthermore, any sort of treatment could only be expected to be successful in cases in which the disease existed in its very incipiency.

Treatment is, therefore, for practical and very obvious reasons not to be thought of as a means of solving the bovine tuberculosis problem.

Under ordinary conditions prevailing in cattle growing, the disease will pursue its natural course and slowly but surely reduce the animal to a state of nonproductivity and subsequent loss of value altogether.

Economic importance.—The economic importance of bovine tuberculosis is to a large extent determined by its prevalence and morbidity rate; at least those factors are the ones which place emphasis on it. It would be a mistake, however, to believe that a low morbidity rate of tuberculosis among a given cattle population is a safe criterion upon which to dismiss the subject as devoid of special interest. Under such conditions it may not be an urgent problem, but a problem it is nevertheless. If it is not so today, it is bound to become so tomorrow, because the disease, unopposed by restrictive measures, always increases its morbidity rate. In no sense is it a self-limiting disease; it does not eradicate itself or recede in the manner of some other animal scourges.

In Nebraska, with a morbidity rate of perhaps not more than 3 per cent, the losses incidental to bovine tuberculosis could no doubt be borne with a certain degree of comfort if its public health relation were left out of consideration and if there were certainty of the present rate remaining stationary. But this rate never remains stationary, and unmolested tuberculosis always increases its incidence. The few data available indicate that in a cattle population of more or less constant numbers the tuberculosis rate doubles every 15 years, and there is good reason to believe that when under similar circumstances the bovine population is a growing one the rate of infection dissemination will even be more rapid.

Morbidity, however, is not the only factor bearing on the economic importance of the disease, and the matter of prevalence must also be given weight.

Nebraska cattle breeders, for instance, should ponder well the fact that in some of the counties where area work was completed the morbidity rate was found to be not more than 4.5 per cent, but that this number of infected animals were distributed over about 25 per cent of the herds in which the tests were made. Under ordinary conditions, such a degree of prevalence would not be long in causing the economic importance of the disease to become actual instead of being merely potential.

To express this economic importance of the disease by statistical methods is impossible because the data required for such a purpose are to a great extent quite intangible or have not been compiled in such a form that they can be made to express the entire toll exacted by the disease.

A few items of the damage done by it are known, however, and they may serve as an index to the cost which tuberculosis imposes not only on the stock grower but on the meat and milk consuming public as well.

The great financial loss caused each year by tuberculosis is reflected by the records of the Federal meat inspection service and these pertain to only about 65 per cent of all the animals slaughtered in the country. They show the following numbers of cattle killed, retained, and condemned on account of tuberculosis, during a series of years:

Fiscal year	Slaughtered	Retained	Condemned
1907 (9 months)	5,867,642	24,876	17,117
1908	7,116,275	68,395	24,371
1909	7,325,337	100,650	24,525
1910	7,962,189	123,501	27,638
1911	7,781,030	133,551	27,186
1912	7,532,005	160,122	35,273
1913	7,155,839	152,560	33,001
1914	6,724,117	143,699	29,738
1915	6,964,502	158,239	32,644
1916	7,404,288	190,991	37,085
1917	9,299,489	218,928	46,351
1918	10,938,287	222,787	40,692
1919	11,241,991	205,698	37,600
1920	9,709,819	200,647	37,492
1921	8,179,572	173,658	33,328
1922	7,871,457	213,606	39,434
1923	9,029,536	251,299	49,839
1924	9,188,652	280,905	56,760
1925	9,773,883	322,925	61,104
1926	10,098,121	419,028	70,604
1927	10,049,589	351,716	53,512
1928	9,040,028	294,002	38,931

During the year 1916 alone the disease caused a total of 3,000 carloads of cattle and hogs to be condemned as inedible at points where Federal meat inspection is being maintained.

In the heavily infected countries of western Europe the losses are sometimes appalling. The total and partial condemnation of beef in Germany during the year 1907 caused a loss of nearly thirty million marks and to this must be added another eight million marks representing the loss in pork because of tuberculosis, which to a large extent was of bovine origin.

As a further indication of the economic importance of the disease when its morbidity rate reaches the one prevailing in the country mentioned, the data supplied by the govern-

ment butcher stock insurance service of Saxony may be mentioned.

Claims arising from tuberculosis during the year 1903 from 107,264 insured female cattle pertained to 43.59 per cent of the total number insured, during the year 1907 from 108,067 head to 79 per cent, and during the year 1910 from 118,597 head to 78.56 per cent.

The relative importance of tuberculosis is further emphasized by the fact that in Germany the total losses caused by such generally feared diseases as anthrax and blackleg amount to no more than one thirty-eighth of those represented by the slaughterhouse condemnation for tuberculosis alone.

The damage arising from the disease in infected herds thru the reduction in the yield of milk and meat and the imperfect utilization of the feed consumed cannot be estimated, however manifest it may be.

As one author on the subject so aptly expresses it, the tuberculous cow may be compared to a defective stove which yields no heat, no matter how much fuel it consumes.

The harm done by tuberculosis to cattle raising is further augmented by the fact that, in proportion to its morbidity in a given herd, the average age of the animals gradually decreases because in such herds the need of eliminating tuberculous animals at a less advanced age occurs with growing frequency.

To all this it must be added that in many sections where the disease is also prevalent in swine a considerable part of the losses associated therewith is chargeable to bovine infection.

The damage inflicted by bovine tuberculosis thru its transmission to children cannot be expressed in number or money values.

Efficient public health measures directed against this transmission are not only a drain on the public purse but a source of no small amount of annoyance to the milk producers as well.

In many parts of the world the losses caused by tuberculosis at this time overshadow those of all other animal diseases; in other parts this condition is rapidly approaching; while in any part where the disease is at all prevalent or existing, the same ultimate result can be expected to come about when the disease is permitted to disseminate without being adequately opposed by measures of suppression and control.

As a menace to the prosperity of the beef producer and dairyman and as an actual or potential tax on the food supply of the people, bovine tuberculosis must now be recognized as a social-economic as well as a public health problem which sooner or later must be solved in all countries and in all states.

PROPHYLAXIS

General principles.—The results of the experimental inquiry into the nature of tuberculosis have brought to light certain facts upon which preventive efforts may be based. Those facts have already been discussed, but on account of their fundamental importance they should again he stated in brief.

Tuberculosis is a transmissible disease capable of being communicated from animal to animal by direct and indirect contact. It is due to a specific germ without which the disease is impossible. This germ, while able to retain life for varying lengths of time when outside the animal body, is an obligate parasite, which cannot multiply unless it inhabits the body of its host. From this it is obvious that the infected living animal constitutes the source from which the disease is transmitted to other individuals.

This infected animal can be successfully singled out by means of the tuberculin test and hence it is possible to eliminate it either by segregation or by slaughter.

While the above factors constitute the foundation upon which the structure of tuberculosis prevention and eradication must rest, there are others of a nonspecific character which must also be given consideration in the struggle against the disease.

They are mainly associated with the conditions under which cattle are being kept. Some of these are especially favorable to the spread of the disease when the infection is at all present and others have a decided inhibitory effect.

Not only does a constant and frequent exposure to the open air reduce the likelihood of infection, but the better aeration of the respiratory mucous membranes renders the localization of bacilli in the terminal air passages and the pulmonary vesicles more difficult.

Cattle kept at pasture thus enjoy a certain measure of protection, and the conditions prevailing there should be approached as far as possible by sanitary stable management and construction. Well-lighted and well-ventilated stables inhibit infection spread and this can be materially furthered by cleanliness and periodic disinfection. Weather permitting, the cattle should be turned out during the day and in the event of particularly mild weather during the night also.

Common watering and feeding troughs should be kept clean and should be frequently disinfected and if the installation of individual utensils is at all possible they should be given preference.

Special precautions should be taken when milk is used for young stock. Unless the absence of infection from the herd

is absolutely known such food should be rendered safe by pasteurization.

Mention should also be made of attempts to protect susceptible livestock against tuberculosis by means of immunization. Interesting as these efforts are, it does not appear that the experiments have as yet reached a phase warranting the practical application of vaccination as a factor in the solution of the tuberculosis problem.

The various methods recently proposed are all of European origin and the experiments are in more or less constant progress and may actually lead to the desired results. To a large extent these many efforts and the continued search for an immunization method reflect the desperate nature of the tuberculosis situation in western Europe. Realizing that the disease may have progressed beyond the possibility of active eradication any means to protect the younger generation of cattle is eagerly searched for.

Before dealing with the subject of prevention and control in detail, attention must be called to the fact that the solution of the tuberculosis problem in all countries by the logical application of what research has brought to light is above all dependent upon an enlightened public opinion and the thoroness of the information on the subject possessed by the owners of susceptible livestock.

The man on the farm above all is the one who determines whether tuberculosis shall be conquered or whether it shall continue to spread. All attempts at eradication by agencies which failed to take cattle owners into their confidence have constantly led to failure; but on the other hand there is good reason to believe that wherever cattle owners thoroly understand the nature of the disease and its actual or potential menace, its total elimination is there only a question of time and of consolidation of efforts.

Neglect of this factor is certainly one of the reasons why so little progress against tuberculosis has been made in wesern Europe, notwithstanding the great excellence of the talent directing the work. A public policy regarding tuberculosis can succeed only when it rests upon public understanding.

Special methods.—Efforts applied to the solution of the bovine tuberculosis problem vary in their mode of approach and differ largely in accordance with its magnitude.

Such efforts may be private or public and they may aim either at complete eradication or at a mere suppression or control.

The greatest promise of success is held out by the intelligent and sustained endeavors in which private initiative and

governmental support and assistance are simultaneously brought to bear on the problem in hand.

In a country like ours in which a preponderating part of its cattle and its herds are as yet free of tuberculosis our principal concern must be to keep them in this happy state and hence our breeders and dairymen cannot be too vigilant in the supervision and management of their herds. Not only should the animals be given the benefit associated with outdoor life and hygienic stable conditions, but each owner will do well to ascertain by one or more tuberculin tests what the status of his animals in regard to tuberculosis really is.

If the disease be present the sooner he is informed about it and its extent the better, because in such a case the earlier the problem is given adequate attention the less will be the damage in the end.

When freedom from tuberculosis, however, can be demonstrated, it becomes a relatively simple matter to maintain this favorable situation indefinitely. The disease can be refused admission to such a herd effectively when all new animals introduced are challenged in regard to their freedom from tuberculosis by tuberculin tests. Such new animals, unless originating from herds known to be free from the infection, should be tested prior to their introduction or immediately after; and when there is the least doubt as to their origin the test should be repeated in 60 days, during which period they should remain in isolation.

Cattle returning from show circuits may be subjected to the same precautions as an additional measure of safety. Attention must also be called to nurse cows introduced into herds of breeding animals for varying periods of service. In order to assure the safety of such a herd such animals should be subjected to tuberculin tests like other new purchases, no matter how short their period of service may be.

Since the establishment of tuberculosis-free accredited herds they may be given preference when new stock has to be purchased for breeding purposes. Animals procured from such herds can be admitted with a minimum of risk of their being infection carriers. Such accredited herds representing practically all breeds are now sufficiently numerous to supply the new blood for herds to be improved without tuberculosis hazards.

Of further importance in the protection of disease-free herds is the care taken with milk introduced from without. No foreign milk should be used without previous pasteurization or sterilization.

All such measures necessarily involve expense, but this amount is trivial in comparison with the costs which in one way or another will have to be met when the disease once has become established in the herd.

Methods to be pursued when infected herds are to be dealt with vary in different countries and even in different herds.

The first rational method devised for such a purpose was proposed by Bang, the great pioneer in the struggle against bovine tuberculosis. It prescribes the absolute separation of the infected herd into healthy animals and tuberculous ones in accordance with the outcome of the tuberculin test, as well as a close scrutiny of the animals for physical signs of the disease.

Animals presenting signs of advanced or marked tuberculosis are eliminated by slaughter, while those which only show evidence of infection by a positive reaction are kept as long as possible or advisable.

The non-reactors are carefully isolated from the infected portion of the herd and measures are taken to make this segregation complete. This freedom from infection is checked from time to time by subsequent tuberculin tests.

Desirable females can be used for breeding purposes, preferably by employing separate bulls for each group. In case breeding to only one bull should be either desirable or necessary, this should always be done on neutral ground and then the contact between the animals should not be prolonged beyond the space of time absolutely required for the purpose.

Calves born from the infected animals must at once be separated from the dams and be fed either with pasteurized milk or with raw milk obtained from non-infected cows. At the most they may receive the colostrum of their dams during the first day and even this does not always appear to be necessary.

The young animals of the entire herd are kept in the open air as much as possible, and it goes without saying that all contact with any possible source of infection is to be rigidly avoided.

The value of the Bang method is particularly associated with the fact that by its application a healthy herd of cattle can be gradually built up even from a badly infected one. In the herds which the writer had occasion to supervise, the method was always successful but proved to be quite irksome to the owners and herdsmen. For this reason the method has never enjoyed popularity in this country and has only found application in herds of exceptional breeding value.

An investigation by the Federal Board of Animal Industry regarding the number of reacting cattle held under segrega-

tion on farms thruout the United States during the year ending June 30, 1923, showed that there were only 201 herds containing 2,461 cattle which were being held for breeding purposes in the entire country. In addition to these there were 191 premises on which 447 diseased cattle were being held for various reasons for an indefinite period. These data show that only 2,908 cattle were on June 30, 1923, being held for a period longer than the usual 30 days. This indicates that our farmers and breeders are not in favor of keeping diseased cattle on their premises.

Owing to differences in the management of herds, labor conditions, and the prevailing morbidity rate, it appears that the Bang method is more suitable to European conditions than to those generally prevailing in this country.

The modification of the Bang method, known as the Ostertag method, has found no application in America. It aims to eliminate from infected herds only so-called open cases or those animals which can be actually proved to cast off bacilli by means of their secretions and excretions. It is employed in Germany, where the great morbidity of bovine tuberculosis makes it perhaps the best method applicable under the circumstances. It reflects in a way the distressful situation prevailing there altho it can be shown not to be devoid of some merit. Under its operation the speed of dissemination is very slowly reduced and this reduction may, in course of time, render more radical methods possible.

Ostertag's method has no place in the American scheme of dealing with the bovine tuberculosis problem, because it would involve too great an expenditure for veterinary services, bacteriologic examinations, and supervisions. At the most it would be a Sisyphus task because the closed case of today is too apt to become the open case of tomorrow, while in addition even the latter may prove to be extremely difficult to detect.

A more radical method than the preceding ones is the one which includes the slaughter of all of the reacting animals so far as they are not reserved and segregated on account of their great breeding value. After the discovery of the tuberculin test it was the first method proposed and to a certain extent applied.

It was soon found, however, that by no means all countries were so situated that they could avail themselves of this means of ridding themselves of the scourge. The high rates of morbidity and prevalence of bovine tuberculosis in many countries render the elimination of the tuberculous part of their cattle impossible on account of the depletion of the milk

supply such a measure would occasion, not to mention the enormous outlay in money needed for reimbursements. Only in countries with as yet a relatively low morbidity rate does the eradication of bovine tuberculosis by radical means come within the range of financial as well as economic possibility. The greater part of the states of the Union find themselves in that favorable position; and while in others the bovine tuberculosis morbidity rate approaches that of western Europe, the situation in the United States as a whole was such that in 1917 Congress could sanction a definite national policy which, with the active co-operation of the states, aimed at the elimination of the disease altogether and could bring the voluntary resort to slaughter on the parts of owners reasonably within their reach.

Prior to 1917, various states had with varying degrees of success coped with the problem within their borders and the Federal government had already excluded tuberculous cattle from interstate traffic and had stopped their importation from abroad. Since that time the system of co-operative effort has unified to a large extent the measures aimed at the solution of the problem.

At first, co-operative effort was concentrated on the pure-bred herds of the country, as it was a well-recognized fact that no other agency had contributed more to the dissemination of the disease than the animals of pure breeding which were sold to farmers for the purpose of herd improvement.

Part of the general scheme of tuberculosis eradication is the accredited herd or honor-roll plan, the principle of which is that herds which have been found to be free from tuberculosis on two successive annual tests can become what is known as accredited. They are placed on an honor-roll and a certificate is given to the owner by the state and Federal government which allows animals of the herds concerned to be moved in interstate traffic without further tuberculin testing for a period of one year.

That this plan is supported by the approval of the breeders of the country is shown by the fact that on November 1, 1927, the accredited herds numbered 142,549, containing about 1,972,000 head of cattle. In addition to this number many herds were in process of accreditation and had completed the first test.

In course of time the funds supplied under the co-operative plan became available for other classes of cattle and the work of eradication gained momentum as desired results were being obtained.

As the picture of the distribution of bovine tuberculosis became more clear thru the accumulation of data obtained

by the testing of millions of cattle, the scheme of clearing entire sections of the country of tuberculosis infection began to have a special appeal both to the owners of livestock and to those actually engaged in the work.

The plan of eradicating tuberculosis from county units is now finding a wide application; and in addition to giving the areas rendered tuberculosis-free certain trade advantages, it contains a promise of hastening the country-wide eradication and of reducing the final cost of the process.

The principal factors which are brought to bear upon the solution of the bovine tuberculosis problem in the United States are: (1) voluntary action on the part of cattle owners who are also provided with the means of acquainting themselves with the nature of the disease by efforts of an educational nature, (2) placing expert counsel and supervision at their disposal without direct cost to them, (3) recognition of the fact that the solution of the bovine tuberculosis problem is not solely a matter pertaining to livestock interests, but that its relation to the national food supply and the public health makes it a matter of government concern, (4) financial assistance to owners enabling and encouraging them to eradicate by slaughter if they do so desire, and (5) co-ordination of private, state and Federal efforts.

No matter whether any method of segregation or slaughter be used in the prevention or control of tuberculosis, it should be emphasized that infected stables, premises, and eating and drinking utensils must also be given adequate attention before disease-free animals are brought in contact with them.

In cases of very defective or unsanitary stables it will often be necessary to make constructional changes or repairs before they can be regarded as a safe environment for animals to live in.

Infection reservoirs.—In the eradication of tuberculosis the greatest value has always rightly been attached to the elimination of infected (reacting) cattle. There can be no doubt that the fountain head of infection can be definitely closed in this manner. Yet, other possible infection sources should be reckoned with and especially so if the tuberculin test shows that tuberculosis exists on a given farm. Swine, for instance, are as apt to contract tuberculosis from cattle as the latter are themselves. If hogs are permitted to become old enough to give the disease time to devlop to such an extent as to cause the infected animals to become spreaders, there comes about an infection source responsible for disappointment when the cattle herd is subjected to the next test.

For this reason, then, in the face of tuberculous infection in the cattle herd the swine on the farm should also be challenged with reference to their freedom from tuberculosis, because an aged sow or boar with an open form of disease is just as apt to be the starting point of a new infection as a tuberculous cow.

Nor should it be forgotten that a clean herd of cattle is always in jeopardy when untested animals are introduced on the same farm. There has been a tendency to forego a critical examination of the type of cattle commonly designated as " feeders " as if such animals were naturally exempt from the disease. This is by no means the case and as long as this type of livestock can be introduced in clean areas without precautionary measures being taken, we must expect that the eradication of tuberculosis will remain a never-finished task.

Among the usually unsuspected infection reservoirs, consideration must also be given to the contaminated environment. The dung-polluted soil of yards which were occupied for long periods by tuberculous cattle and swine is apt to contain a not inconsiderable number of bacilli which remain alive and possibly virulent for a long time. Such germs taken in by the subsequent occupants of the premises may cause new cases of the disease to develop or in the event of the virulence having been lost during their sojourn in the soil they may sensitize the animals which take them in, so that they may react positively to a subsequent tuberculin test. It is not improbable that at least a part of the unaccountable reactions in animals without recognizable lesions can be attributed to such an avirulent environmental infection. There is good ground for the belief that yards which have been exposed to the type of contamination described above should be abandoned for a number of years at least.

Results.—That herds can be freed of tuberculosis and kept free thereafter by the prophylactic measures discussed has been apparent for many years. A considerable number of herd owners have managed tuberculosis-free herds for years and have given proof that the measures of tuberculosis prevention now widely applied in the coöperative campaign are based upon sound foundations and that their practical application is an almost certain means of solving the problem. The herds freed from and protected against the disease for years, as it were, served as laboratories where methods proposed could be tested and where results were obtained which justified the larger undertaking of nation-wide eradication.

The good results following individual attempts did not bring about an appreciable reduction in the general morbidity rates of the country as a whole because, compared with the cattle population as a whole, they were too few in number.

In some states, however, where public efforts could support private initiative for a number of years, the prevalence and morbidity of bovine tuberculosis were certainly and materially reduced.

The record of the Livestock Sanitary Board of Minnesota, where the disease has been eliminated from pure-bred cattle to a considerable extent, shows that during the fiscal year 1908 out of a total of 27,216 grade and purebred animals tested 9.4 per cent reacted. Out of a total of 65,968 cattle tested during the fiscal year 1918, 2.4 per cent reacted. Similar work has been in progress in the state of North Dakota for a number of years. These two states contribute the bulk of the receipts of cattle and swine at the South St. Paul market; and it is significant that while 3.8 per cent of the cattle killed during the year 1918 at the three northern markets of Chicago, Milwaukee, and Sioux City were found on post-mortem examination to be affected with tuberculosis, only 1.9 per cent of all the cattle killed at the St. Paul market during the same year were found to be affected with the disease.

After two and a half years of systematic control effort under the cooperative plan, Kiernan and Ernest could report in 1919 that already an appreciable effect on the losses occasioned by the disease could be observed. Their calculations at that time warranted them in saying that had the spread of tuberculosis been allowed to continue at the same rate that it progressed from 1907 to 1917, by 1937 the disease would undoubtedly have exacted an annual toll from livestock products of this nation of one hundred millian dollars and that this would have been only a part of the loss. As a result of the country-wide efforts in eradication the 2.4 per cent tuberculous infection found in cattle during the year which preceded the inauguration of the campaign has by 1927 been reduced to 1.1 per cent. The most hopeful achievement of the struggle against the disease is, no doubt, the elimination of a major part of the chief infection sources which flourished prior to 1917, namely, the badly infected purebred and dairy herds. This accomplished, the incidence of bovine tuberculosis in the United States should, and no doubt will, progressively decline, provided our present-day efforts can be sustained.

BOVINE TUBERCULOSIS IN OTHER ANIMALS

As a rule the bacillus of bovine tuberculosis displays a greater degree of virulence toward other mammals than does the one of human origin. There are considerable variations in the susceptibility on the part of the domestic animals and

this is also reflected by the degree of morbidity shown by the different species.

After artificial infection with bovine tubercle bacilli, the susceptibility of sheep and goats does not differ from that of the bovine species, while they are much more resistant to the human bacillus. In fact some investigators are of the opinion that those animals can be used to advantage to distinguish the two types of tubercle bacilli from one another.

For dogs the bovine infection appears to be equally as virulent as the bacillus obtained from human sources but cats are probably susceptible to the bovine strain only.

The spontaneous infection of farm mammals is in the preponderating portion of the cases due to bovine infection altho human infection is not always to be excluded, especially not in such animals as the dog and cat, which by their close association with man may be particularly exposed.

Only in the case of swine does bovine tuberculous infection become a problem of great economic importance. In the transmission of bovine infection, the latter is nearly always of alimentary origin, the contact coming about by the consumption of milk of infected cows and by the contamination of foodstuffs by the dung of infected cattle such as is not infrequent wherever hogs and tuberculous cattle occupy the same feeding yards.

While for a long time tuberculosis in swine was regarded as being almost exclusively caused by bovine infection, evidence has in recent years come to light that this is by no means the only important source of the disease in hogs.

In several cases of tuberculosis in the horse the history of the infectd animals indicates that they contracted the disease thru close cohabitation with tuberculous cattle. Horse tuberculosis is most common where cow's milk is used as a feed for colts and sick adult horses.

In dogs and cats tuberculosis is often of alimentary origin and even one infected meal may bring about the tuberculous infection when the food contains great numbers of bacilli, such as is often the case when tuberculous organs or milk are consumed in considerable quantity.

Tuberculosis has been observed in goats and sheep, when those animals have been kept for long periods in stables inhabited by tuberculous cattle or when they have received feed contaminated with bovine excretions.

BOVINE TUBERCULOSIS IN MAN

While in this publication the problem of bovine tuberculosis is above all presented in the light of its great destructiveness to farm livestock and on account of its indirect bearing on the national supply of milk and meat, its relation to

the public health is certainly sufficiently close to warrant a brief review of the facts which have become known regarding the transmission of tuberculosis from cattle to man.

During the years following the discoveries of Villemin and Koch, the transmission of bovine tuberculosis to man was accepted as a matter of course. This transmission was, however, again brought in question by no one less than Koch himself, who in 1901 declared that such a transmission need not be feared because the two types of infection did not appear to be identical and further because of the relatively rare occurrence of intestinal tuberculosis in man.

Koch's views also received some support from the fact that even prior to 1901 it had become known that the bovine and human bacilli differed to a certain extent in their manner of growth on artificial media as well as in their disease-producing qualities when inoculated into experimental animals.

The position taken by Koch caused the whole question to be studied anew and the matter of bovine infection transmitted to man was subjected to thorogoing inquiry the world over.

In brief, the results of great numbers of investigations proved the position taken by the great pioneer to be without foundation and it was found indeed that bovine tuberculosis does play a part as a source of origin of the human disease.

Cases of tuberculosis apparently transmitted from cattle to man had been recorded for many years, but from 1901 on attempts were made to identify definitely the nature of the infection found in man by a study of the bacilli which could be isolated from the lesions. The two types of bacilli, both varieties of the same bacterial species, are not easy to differentiate either by their mode of growth or by their behavior when inoculated into animals and hence it is quite possible that the results obtained by the various investigators are somewhat vitiated by a considerable factor of error.

As the influence of such errors operates in the same manner for both types of infection as identified, the conclusions reached by the various workers are perhaps not far from representing the actual part played by either human or bovine bacilli in human tuberculosis.

Error in interpretation of results or differences in the methods of investigation may account for some variations in the incidence of bovine tuberculosis in man as revealed by authors who obtained their material in different parts of the world, altho it is by no means impossible that such variations are due to factors relating to the population from which the lesions were taken and to certain details pertaining to their ways of living and the modes of food preparation.

At any rate it is quite apparent that infection due to the bovine bacillus varies in frequency in different countries and that it is, for example, far more common in New York, London, and Edinburgh than it is in Paris.

When the results of the various investigators are subjected to analysis there can, however, be no doubt that the bovine type of infection is extremely rare in the chronic pulmonary tuberculosis of adult man on the one hand and on the other that this type of infection is relatively frequent in the acute tuberculosis and glandular infections of early age.

Infection of bovine origin is thus above all to be feared in children, and this not only because they are more exposed to the virus conveyed to them by infected milk, but also by reason of their greater susceptibility to intestinal infection on account of the greater permeability of their digestive organs. In adult man, bovine infection appears to play a less important part.

This influence of age is quite apparent from the data gathered by Park and Krumwiede in 1911 and which pertained to no less than 1,224 cases occurring in different countries and in which the type of infection was determined.

Here follows a summary of the results of their analyses:

Adults of more than 16 years		Children from 5-16 years		Children less than 5 years	
Origin of infection		Origin of infection		Origin of infection	
Human	Bovine	Human	Bovine	Human	Bovine
777	10	117	36	215	65

Mixed infection, 4 cases — Total, 1,224 cases

Investigations made by A. Philip Mitchell of Edinburgh on the origin of glandular (neck) affections in 72 children yielded the following results:

Age in years	Origin of infection		
	Human	Bovine	Total
0– 1	2	1	3
1– 2	..	16	16
2– 3	..	8	8
3– 4	1	10	11
4– 5	..	4	4
5– 6	1	4	5
6– 7	..	5	5
7– 8	..	5	5
8– 9	..	5	5
9–10	1	4	5
10–12	2	3	5
Total	7	65	72

Material obtained from the Royal Hospital for sick children and the Royal Infirmery at Edinburgh studied by Chung Yik Wang and the previous studies by other investigators in the same city, altogether pertaining to 281 cases of various forms of tuberculosis, showed the presence of the bovine bacillus in 78.4 per cent of the cases below the age of 5 years, in 70.3 per cent of the cases between the ages of 5 and 16, and in 7.8 per cent of the cases over 16 years of age.

Abdominal tuberculosis and tuberculous meningitis were altogether responsible for about 90 per cent of the mortality from tuberculosis in children below 1 year of age and for about 75 per cent of that in children between the ages of from 1 to 5 years. The material from 9 children dead from these 2 forms of tuberculosis was examined bacteriologically by this investigator and from 6 of them could the bovine type of bacilli be isolated.

Fraser of the same city studied 67 cases of bone and joint tuberculosis and found bovine infection in 42 cases, human infection in 22 cases, while 3 cases yielded both types of infection. Of 43 bottle-fed infants, 35 yielded the bovine bacillus, 3 yielded the human bacillus, and 3 both types of infection. On the other hand, of 26 breast-fed infants, the human type was found in 19 and the bovine type in 7 cases.

Of 46 infants belonging to families in which tuberculosis

did not previously exist, 43 showed bovine infection, while of 21 cases of tuberculosis in children belonging to tuberculous families only 6 showed the bovine bacillus.

According to Kossel the bovine bacillus is found in only 4.3 per cent of the cases of bone tuberculosis, in 10.7 per cent of those of tuberculous meningitis, in 23.8 per cent of the generalized cases, in 40 per cent of tuberculosis of the lymph nodes of the neck, and in 49 per cent of the cases of abdominal tuberculosis.

Cummins concluded that bovine tuberculosis is responsible for only about 17 per cent of the pulmonary cases in man, but for 18 per cent of the meningitis cases, for 21 per cent of the bone and joint cases, for 51 per cent of the abdominal cases, and for 50 per cent of the cases of tuberculosis of the lymph nodes of the neck. On the other hand, pulmonary tuberculosis, which is practically always of human origin, is responsible for about 80 per cent of the total death rate from the disease.

De Besche of Christiania estimates that from 6 to 8 per cent of human tuberculosis has a bovine origin. On the other hand, Ungermann could isolate the bovine bacillus from only 2 of the 171 cases of cervical gland tuberculosis occurring in children from 3 weeks to 12 years of age, while Steffenhagen found the human bacillus in 35 and the bovine bacillus in only 5 of the 40 cases of glandular tuberculosis in infants.

Burnet of Paris was able to isolate the human bacillus from 31 cases of glandular tuberculosis, from 11 cases of joint tuberculosis, and from 16 cases of tuberculosis in the skin. In not a singe case did he find the bovine bacillus, altho the material investigated pertained exclusively to children.

From this it appears that in some sections, at least, the population is quite exempt from bovine tuberculosis, even if the cattle population shows a high morbidity. To what extent this phenomenon may be due to the heating of milk used in infant feeding is not shown by the evidence.

A more recent contribution to the knowledge of bovine tuberculosis in man was made by Griffith at the National Milk Conference held at London in 1922.

Griffith had at his disposal the material of 1,200 cases in which the type of infection had been determined. From this material he could conclude that bovine bacilli caused a part of the cases of human tuberculosis and are capable of giving rise to the disease in every organ, every joint, and every gland and cannot be clinically differentiated from the changes caused by human infection.

Among other things he found that in children less than 5 years old, the bovine type of infection is revealed in more than

80 per cent of the cases of tuberculosis of the lymph nodes of the neck and in those of abdominal tuberculosis.

In lupus (tuberculosis of the skin) the bovine type was found in 50 per cent of the cases, while the same type of infection was found to be responsible for from 16 to 20 per cent of the cases of tuberculosis of joints, of the genito-urinary organs, and of the meninges.

However the results of the different investigators may vary in the percentage of bovine infection found in human cases, it is certain that at least this source of tuberculosis deserves serious consideration. For example, in Germany a total of 27,200 infants die of tuberculosis annually; and even if the low estimate by Orth that 10 per cent of infantile tuberculosis cases are due to bovine infection in that country be correct, then the deaths of 2,700 children are to be charged to the account of bovine tuberculosis each year.

Cobbett estimates that in England and Wales 6.5 per cent of all deaths from tuberculosis can be accounted for by bovine infection, so that the latter becomes responsible for an annual loss of about 3,000 children in the area mentioned. More recently it was found that of sixty cases of extra-pulmonary tuberculosis of man, analyzed by Morrison, not less than thirty-four were due to infection by the bovine bacillus and that the latter accounted for three-fourths of the cases of tuberculosis of the lymph nodes of the neck. In all probability the incidence of bovine infection in man in the United States as a whole is less than in the countries cited and if this be so it can be accounted for by the smaller morbidity rate of the bovine tuberculosis which prevails in this country as compared with that of western Europe.

This relatively low incidence of tuberculosis in this country is reflected by what appears to be a minor part played by bovine infection in the non-pulmonary tuberculosis in man. Among the 151 cases of human tuberculosis examined at the Nebraska Experiment Station there were five in which bovine infection could be definitely established. There can be no doubt that this low incidence of bovine tuberculosis in man could not be maintained if the disease in cattle were permitted to increase.

When the subject of tuberculosis is viewed in all its aspects, it is apparent that the problems presented by both the human and the bovine disease cannot be separated when their solutions are seriously contemplated.

The situation cannot be more adequately stated than by borrowing from an expression by Kossel, who said in substance: In case we really succeed in completely preventing the danger of infection from animal sources by prophylactic

measures, tuberculosis will still remain the same spreading disease of people. After the elimination of cases of bovine origin, human tuberculosis would indeed be no longer the same but still would be a spreading scourge of man. However, a disease generally to be combated (tuberculosis of children, lupus) would still be left if even all bacilli of the human type were destroyed, because tuberculosis of the human race cannot disappear as long as bovine infection can constantly be transmitted from animals to man.

BOVINE TUBERCULOSIS AND MEAT AND MILK HYGIENE

Meat.—While the muscle tissues of tuberculous cattle rarely participate in the disease process, it is by no means infrequent that the bacilli are present in the meat.

This presence may be due to various factors. In acute miliary tuberculosis, in which the blood current conveys the organisms, the latter may also find their way into the muscles and in such cases the juice which can be pressed out of the tissue may be found to be virulent. Such a dispersion of the bacilli may also come about by the softening of tuberculous lesions followed by the entrance of the organisms into eroded blood vessels, and in this connection, it does not appear to be necessary that the lesions be of considerable dimensions. The fact of their being numerous is sufficient to cause bacilli to find their way into the muscles either more or less constantly or periodically.

The tubercle bacilli may be contained in the lymph nodes situated between the various muscular masses. Such lymph nodes may or may not be tuberculous. If so, it is obvious that the meat may be virulent, but it has also been shown that in emaciated tuberculous animals the lymph nodes as well as the muscle tissue surrounding them were virulent altho of entirely normal appearance.

In addition to the ways in which meat may be caused to contain the bacilli by the natural processes of the disease and the dissemination of the organisms thruout the muscles, the meat may become contaminated during the handling and the various manipulations of butchering.

Decker, for instance, found that of 47 butcher's tools 19 were polluted with virulent bacilli while of the knives 76.59 per cent were contaminated.

The organisms adhering to knives and to the hands can be readily transferred to the surface of the meat and many thus find their way to the consumer. Such contamination, however, constitutes but little infection danger because the least degree of cooking brings about the prompt destruction of the bacilli. Only when the meat is eaten in the raw state may there be some risk of infection.

Many experiments with a great variety of animals have shown that tuberculosis can be transmitted by the eating of meat of tuberculous cattle. Yet it does not appear that such meats offer more than a very slight danger to man. This is largely due to the fact that at least in this country meats are habitually cooked before being eaten as well as to the fact already mentioned, that adult man is quite resistant to bovine infection. The latter circumstance, no doubt, is also responsible for the fact that accidental infection thru wounds and abrasions of the hands of butchers, meat handlers, meat inspectors, and veterinarians is not more common and that when it does occur the consequences are not more serious than what they often are.

While the risk to human health arising from the handling and eating of the meat derived from tuberculous animals is but slight, the demonstrated virulence of meat products of extensively affected animals or of those in which the lesions indicate a possible dissemination of bacilli thru the body by the blood stream has led to their exclusion from consumption in most civilized countries in the interest of the public health as well as for purely esthetic reasons.

As the greater part of the meat consumed in the United States is prepared in establishments where the Federal government maintains systematic inspection of the animals before and after slaughter, it may not be amiss to point out briefly how carcasses and parts of carcasses found to be tuberculous are disposed of.

The task of the meat inspection service of the United States government is to provide the greatest possible protection of the public health, to fulfill the esthetic requirements rightfully imposed by the consuming public, and to do so with a minimum amount of destruction of valuable and highly necessary foodstuffs. The regulations and practices now enforced and prevailing tend to accomplish the purposes mentioned.

The following principles are declared for guidance in dealing with carcasses affected with tuberculosis:

No meat is to be used for food if it contains tubercle bacilli or if there is a reasonable possibility that it may contain the same or if it is impregnated with toxic substances of tuberculosis or associated septic infections.

Meat should not be destroyed if the lesions are localized and not numerous, if there is no evidence of distribution of tubercle bacilli thru the blood or by other means to the muscles, and if the animal is well nourished and in good condition.

Evidences of generalized tuberculosis are to be sought in

such distribution and number of tuberculous lesions as can be explained only upon the supposition of the entrance of tubercle bacilli in considerable number into the circulation.

Localized tuberculosis is tuberculosis limited to a single or several parts or organs of the body without evidence of recent invasion of numerous bacilli into the circulation.

The entire carcass is condemned if any of the following conditions are present:

When before the killing the animal was suffering from fever or wasting of the body tissues.

When the lesions of tuberculosis are generalized as shown by their presence not only at the usual seat of primary infection but also in parts of the carcass or in the organs that may be reached by the bacilli of tuberculosis only when they are carried in the systemic circulation. When tuberculous lesions are found in the muscles or inter-muscular tissue or bones or joints or in the body lymph nodes as a result of such lesions. When the lesions are extensive in one or in both body cavities. When the lesions are multiple, acute and actively progressive.

An organ or a part of carcass is condemned under the following conditions: When it contains tuberculous lesions or when the lesion is localized but adjacent to the flesh. When it has been contaminated by tuberculous material thru contact with the floor or soil or a soiled knife or otherwise. When lymph nodes receiving the lymph drain of the organ are tuberculous.

Carcasses showing lesions of tuberculosis should be passed for food when the lesions are slight, localized, and calcified or encapsulated or are limited to a single or several parts or organs of the body and there is no evidence of recent invasion of tubercle bacilli into the systemic circulation.

When carcasses reveal more severe lesions than the ones mentioned above but not so severe as to warrant total condemnation, they may be rendered into tallow or otherwise sterilized provided the distribution of the lesions is such that all parts containing tuberculous lesions can be removed.

Milk.—Cow's milk, because of its relation to bovine tuberculosis, occupies an important position among the various vehicles which may be instrumental in the transmission of the disease from animal to animal and from animal to man.

From a public health point of view this importance is further emphasized by the fact that milk so often is the principal article of diet, if not the sole one, of infants and children, who in accordance with the evidence already submitted appear to be more susceptible to bovine infection at

that age than during the ages of adolescence and adult life. Without doubt the great majority of the cases of human tuberculosis caused by bovine infection are the result of the ingestion of infected milk.

Especially in cases of udder tuberculosis can the infectiousness of the milk be accepted as a matter of course. Milk derived from the tuberculous udder may be extremely rich in bacilli. As many as 100,000 tubercle bacilli have been found to be contained in one cubic centimeter of milk and in some instances it was still possible to prove its virulence when the original product was diluted one billion times.

But not only do the cows with tuberculous udder disease eliminate the bacilli thru the milk. Many investigations have resulted in showing that cows without appeciable udder lesions but reacting to the tuberculin test may yield a milk in which tubercle bacilli are present.

In such animals the elimination of the bacilli thru the milk may not be a constant feature; in fact, it frequently is of an intermittent character.

For practical purposes, therefore, the milk of a reacting cow must always be looked upon as a real or potential means of conveying the infection to other animals or to man. It must be regarded as a source of danger to infants and children when consumed in the raw state in considerable quantities and during a prolonged space of time.

Milk not only becomes contaminated by tubercle bacilli within the udder of the tuberculous cow, but it may become thus polluted after being drawn by stable dust or fecal matter during the act of milking in infected stables.

As has already been pointed out, bacilli can escape from the tuberculous animal by means of the bowel discharges, and in infected stables this material is very apt to contaminate the milk of the healthy members of the herd.

Thus not only does the milk of the tuberculous cow constitute a source of danger to other animals and man, but the milk of a stable or herd in which the disease is present can never be regarded as absolutely harmless even if it were known that the animals producing it were free from infection.

To what extent such milk products as ice-cream, butter, and cheese prepared from the milk of tuberculous cows are responsible for the infection of children is not known. It has been shown that tubercle bacilli contained in milk are apt to adhere to the fat globules and can be recovered from the cream of such milk in large numbers.

Butter prepared from the milk of tuberculous cows is looked upon with suspicion by certain investigators, as its virulence has been proved by experiments on laboratory

animals. In those experiments it was further shown that the virulence was maintained by the bacilli contained in butter for about 100 days.

In cheese manufactured from tuberculous milk, the bacilli could be shown to be virulent after 220 days, but after 261 days the disease-producing quality had largely disappeared.

The dangers connected with the milk of tuberculous cows has brought about the adoption of special measures for the protection of the public health by legislative enactments on the part of municipalities and states, Nebraska being included among the latter.

As a rule, such measures prescribe that milk may be sold only after pasteurization or when the freedom from infection of the animals producing it is established by means of the tuberculin test. Both measures mentioned, if carried out thoroly and competently, can be depended on to eliminate the danger associated with the milk supply.

Pasteurization has been opposed by some authorities on the ground that it renders the milk less fit for the purpose of infant feeding by the destruction of its vitamins, a theory entirely rejected by others.

The principal disadvantage connected with pasteurization is probably caused by the need of constant official supervision and controi, which, added to the cost of the process itself, tends to increase the selling price of milk, and a high price of milk is not uncommonly an important factor in the underfeeding of children, a thing to be prevented above all.

Pasteurization, however efficient in its ultimate results as far as tuberculosis is concerned, must be looked upon as a makeshift measure. The final solution of the tuberculosis phase of the milk problem is the eradication of the disease itself.

When the tuberculous cow has gone the way of the glandered horse and the Texas fever steer and when tuberculosis of farm livestock has disappeared like contagious pleuropneumonia, rinderpest, and foot-and-mouth disease, public health authorities and legislatures will be able to dispense with most of the measures which now plague both the producer and the consumer of milk the country over.

In that direction lies the only solution of the bovine tuberculosis problem that can be looked upon as furnishing protection of the public health, of the national meat and milk supply, and of our stock growing industry.

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